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CR-142916

(E75-10314) RESEARCH AND INVESTIGATION OF GEOLOGY, MINERAL, AND WATER RESOURCES OF MARYLAND Final Report (Maryland Geological Survey, Baltimore.) 107 p HC $5.25 CSCL 08G

N75-26458

Unclas
G3/43 00314

Research and Investigation of Geology,
Mineral and Water Resources of
Maryland

Kenneth N. Weaver, Prin. Invest. MCC
401: Maryland Geological Survey

September, 1974

Final Report

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Research and Investigation of Geology, Mineral, and Water Resources of Maryland

Dr. Kenneth N. Weaver, Principal Investigator
Maryland Geological Survey
The Johns Hopkins University
Baltimore, Maryland 21218

September, 1974
Final Report

Prepared for
Goddard Space Flight Center
Greenbelt, Maryland 20771

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle DIFFERENTIATION OF SERPENTINITIC FROM NON-SERPENTINITIC ULTRAMAFIC ROCKS IN ERTS-1 MSS IMAGERY		5. Report Date
		6. Performing Organization Code
7. Author(s) William P. Crowley		8. Performing Organization Report No.
9. Performing Organization Name and Address Maryland Geological Survey The Johns Hopkins University Baltimore, Maryland 21218		10. Work Unit No.
		11. Contract or Grant No. NAS5-21848
12. Sponsoring Agency Name and Address Goddard Space Flight Center Greenbelt, Maryland 20771		13. Type of Report and Period Covered Final Report September, 1974
		14. Sponsoring Agency Code

15. Supplementary Notes

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16. Abstract

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17. Key Words (Selected by Author(s))	18. Distribution Statement
Serpentinitic rocks Non-Serpentinitic rocks Land-use pattern	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*

TECHNICAL REPORT STANDARD TITLE PAGE

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7. Author(s) Jonathan Edwards, Jr.		8. Performing Organization Report No.
9. Performing Organization Name and Address Maryland Geological Survey The Johns Hopkins University Baltimore, Maryland 21218		10. Work Unit No. 11. Contract or Grant No. NAS5-21848
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Two prominent sets of linear features are detected on ERTS-1 imagery. One set is comprised of two belts trending N45°E and are composed of Sam's Creek Metabasalt (western belt) and quartzose facies of the Wissahickon Schist (eastern belt). The second set of linear features is detected between the western and eastern belts of the first set and trend N20°E. These subtle features, such as lineaments, maybe of significance not only in the interpretation of the regional geology, but also may have practical importance in environmental geology, such as indicating zones of high groundwater yields, mineralization, or shattered and deeply weathered bedrocks.

17. Key Words (Selected by Author(s))	18. Distribution Statement
Lineaments Sam's Creek Metabasalt Wissahickon Schist	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle *MARYLAND CHESAPEAKE BAY BEACHES - GENERAL DISTRIBUTION AND CLASSIFICATION*		5. Report Date 6. Performing Organization Code
7. Author(s) *Randall T. Kerhin & Turbit H. Slaughter*		8. Performing Organization Report No.
9. Performing Organization Name and Address *Maryland Geological Survey* *The Johns Hopkins University* *Baltimore, Maryland 21218*		10. Work Unit No. 11. Contract or Grant No. *NAS5-21848*
12. Sponsoring Agency Name and Address *Goddard Space Flight Center* *Greenbelt, Maryland 20771*		13. Type of Report and Period Covered *Final Report* *September, 1974* 14. Sponsoring Agency Code

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Research and Investigation of Geology, Mineral and Water Resources of Maryland. Dr. Kenneth N. Weaver, Prin. Inv.

16. Abstract

The effectiveness of ERTS-1 multispectral imagery to detect small-scaled beach features with strict manual image interpretations is dependent on two factors; the contrast at the land/water interface and the linearity of the beach system. Through ground truth verification, four misinterpretations are recognized. The most common condition for misinterpretation of the beach signature is fill material behind a bulkhead. The other misinterpretations are nearshore turbidity, vertical sedimentary cliffs, and shoreline erosion control structures.

Based on ERTS-1 imagery and aircraft support data, beaches of Chesapeake Bay are classified as broad and narrow beaches based on the width of the backshore zone. The predominate beach type is narrow beaches existing throughout the Bay while the broad beaches are confined to the western shore. The broad beaches accounted for 121 Km of beach length and are dominate in Calvert and St. Mary's counties. With the use of ERTS-1 imagery, actual ground truth mapping is not needed for a major beach system and ground truth observations can be concentrated in areas of misinterpretation.

17. Key Words (Selected by Author(s)) *Chesapeake Bay* *Beaches* *Classification* *Distribution* *Narrow* *Broad*	18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle *THE RELATIONSHIP OF NEARSHORE LONGSHORE BAR AND SAND WAVES ALONG OCEAN CITY, MARYLAND*		5. Report Date
		6. Performing Organization Code
7. Author(s) *Turbit H. Slaughter*		8. Performing Organization Report No.
9. Performing Organization Name and Address *Maryland Geological Survey* *The Johns Hopkins University* *Baltimore, Maryland 21218*		10. Work Unit No.
		11. Contract or Grant No. *NAS5-21848*
		13. Type of Report and Period Covered *Final Report* *September, 1974*
12. Sponsoring Agency Name and Address *Goddard Space Flight Center* *Greenbelt, Maryland 20771*		14. Sponsoring Agency Code
15. Supplementary Notes *Research and Investigation of Geology, Mineral and Water Resources of Maryland. Dr. Kenneth N. Weaver, Prin. Inv.*		

16. Abstract

This report has shown by comparing historical shorelines of Ocean City, from the inlet to the Maryland-Delaware line that reversal zones of erosion and accretion occur at different locations for different periods. The Atlantic Ocean coastline assumes at times a crescentic form called sand waves whose existence is related to shape and location of the nearshore bar. Because of climatic and wave conditions, the offshore bar is changed causing oblitoration of the sand waves. The sand waves in response to bar metamorphosis change size, location, and existence.

17. Key Words (Selected by Author(s))	18. Distribution Statement
Sand Waves *Longshore Bar* *Reversal Zones* *Atlantic Ocean Coastline*	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*

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Research and Investigation of Geology, Mineral and Water Resources of Maryland. Dr. Kenneth N. Weaver, Prin. Inv.

16. Abstract

Using ERTS-1 multispectral imagery and aircraft support, the distribution of the high reflectance levels (high marsh-high topographic areas) for the Lower Eastern Shore are distributed as two distinct trending linear ridge systems. On the western side of Tangier Sound the linear ridges trend in a northwest-southeast pattern and on the eastern side the linear ridges trend in a northeast-southwest pattern with a projected convergence at the Maryland-Virginia line. The northeast-southwest trending linear ridges on Janes Island were selected as a ground truth site for signature return and vegetation type correlation. The linear ridges correlate with high marsh/upland vegetation and appears on the aircraft support and ERTS-1 imagery as high reflectance levels. A shallow stratigraphic section of a linear ridge displays 10-20 cm root zone followed by a brown-tan to gray clay layer to 89 cm overlying a red-stained medium sand. The intersection of the linear ridge with the shoreline exposes a wave-cut bench of the root zone and brown-tan clay found in the cross-section.

17. Key Words (Selected by Author(s))	18. Distribution Statement
High marsh vegetation *Linear ridges*	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*

TECHNICAL REPORT STANDARD TITLE PAGE

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4. Title and Subtitle VISUAL OBSERVATIONS OF THE SUSPENDED SEDIMENT AND NEARSHORE ICE SIGNATURES IN CHESAPEAKE BAY		5. Report Date
		6. Performing Organization Code
7. Author(s) Randall T. Kerhin		8. Performing Organization Report No.
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Research and Investigation of Geology, Mineral and Water Resources of Maryland. Dr. Kenneth N. Weaver, Prin. Inv.

16. Abstract

Observations of MSS band 5 dated April 9, 1974 exhibited an unique sedimentation pattern for Chesapeake Bay. Following a 1.5 inch rainfall, heavy concentration of suspended sediments is observed on the imagery, particularly in the area of the turbidity maximum. At some of the major tributaries, a suspended sediment wedge is observed showing an upstream transportation direction.

During January and February, 1973, a freeze-thaw-freeze condition existed with beach and nearshore ice observed on ERTS-1 imagery. Beach ice can be mistaken for a beach signature on MSS band 7 and nearshore ice can be misinterpreted as nearshore turbidity on MSS band 5.

17. Key Words (Selected by Author(s))	18. Distribution Statement
Suspended sediments Beach and nearshore ice	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*

Table of Contents

Page

PREFACE

OBJECTIVE

The overall objective of the ERTS-1 investigation by the Maryland Geological Survey is to apply and evaluate ERTS-1 imagery to specific research projects of the Environmental Geology and the Coastal-Estuarine Geology Programs. The specific objectives are:

1) Environmental Geology Division-application and evaluation of ERTS-1 multispectral imagery to geological mapping of portions of the Maryland Piedmont.
2) Coastal-Estuarine Geology Division-application and evaluation of ERTS-1 multispectral imagery to inventoring and mapping beach and nearshore depositional features of Chesapeake Bay and the Atlantic Ocean with emphasis on baseline data acquisition of depositional features and coastal processes.

SCOPE OF WORK

The primary method of data extraction from ERTS-1 imagery was accomplished by manual image interpretation of 9 x 9 bulk processed positive transparencies. Geological mapping involved constructing direct overlays to scales of 1:1,000,000 and 1:250,000 with ERTS-1 MSS Bands 5, 7, and color composite. Color additive enhancements were made for select scences using an I^2S color additive viewer at the Chesapeake Bay Data Center, Wallops Station, Virginia. Active ground truth and aircraft support photographic data complemented manual image interpretation of ERTS-1 imagery.

In the Environmental Geology program, geological mapping was confined to portions of Maryland Piedmont particularly Baltimore and Carroll counties.

In the Coastal-Estuarine program, beach distribution maps were constructed for the entire Chesapeake Bay with detailed analysis of two select sites, Calvert County and Kent Island, Queen Annes County. Specific investigations of the linear ridge systems and sand waves fields were limited to the Lower Eastern Shore and the Atlantic Ocean from Ocean City inlet to the Delaware-Maryland Line, respectively.

CONCLUSIONS

A major objective of the Environmental Geology Program is detailed geological mapping at scales of 1:24,000 and 1:62,500 in selected areas of Maryland. Through manual image interpretation, the differences of scales of ERTS-1 imagery to geological mapping became a major problem in resolving subtle geological features. The main application of ERTS-1 imagery is to regional mapping of structural and bedrock geology. As stated in the first two sections, geological mapping is in a sense mapping vegetation differences and their respective signature returns. In areas of Western Maryland Piedmont, subtle vegetation differences based on lithology differences are not visible in the ERTS-1 imagery and the general procedure of vegetation-geological mapping is very difficult. For Western Maryland Piedmont, the major application of ERTS-1 imagery is detection of regional structural features such as fold culminations and lineaments. These structural features are important from the aspect of mineralization and mineral resources. Although ground truth was not initiated for the structural geology, ERTS-1 imagery supplied the baseline data needed for a clearer understanding of these subtle structural features.

Generalized mapping and detection of coastal geomorphic forms has been successfully applied to the Chesapeake Bay region. Through the primary use of MSS band 7 and MSS color composite, beach distribution maps for Chesapeake Bay and linear ridge distribution maps for the tidal salt marshes for the Lower Eastern Shore have been produced. The generalized beach distribution maps permitted delineation of the major beach systems which in turn allows greater percentage of ground truth time into areas of questionable interpretation. The linear ridge systems for the Lower Eastern Shore were detected on ERTS-1 imagery by delineation of high marsh vegetation signature returns. The linear ridges are distributed in two trends, a northeast and a northwest trend direction. Attempts to map nearshore bedforms proved unsuccessful from ERTS-1 imagery due to the small-scaled nature of the bedforms and interference of scan lines and nearshore turbidity. Small-scaled sand waves along the Atlantic Ocean coastline were mapped primarily by low-level aircraft support. As noted by many investigators, MSS band 5 is successful in delineation of suspended sediment patterns. Some observations were made on suspended sediment pattern but because of lack of technical experience, facilities and adequate ground truth, these observations need further investigation for any conclusive interpretation. The ERTS-1 investigation has shown successfully that manual image interpretation can supply a data base in which further research investigations can be compared and planned.

RECOMMENDATIONS

The major recommendation deals with scale and resolution of ERTS-1 imagery. Generally the scale differences and resolution limits are beyond

the scales of the geological mapping program. It is recommended that if good resolution can be maintained through enlargements of ERTS-1 imagery scale of 1:1,000,000 to a mapping scale of 1:62,500 a greater application of ERTS-1 imagery to geological mapping is foreseen. The resolution limits of ERTS-1 is not applicable to mapping small-scale coastal geomorphic features of Chesapeake Bay and improved resolution is recommended. In the investigation of coastal sedimentation, ERTS-1 is very applicable to suspended sediments but beach and nearshore sedimentation is not adequately recorded on the imagery. More emphasis on beach sedimentation with respect to multispectral technology, ground truth techniques and interfacing with ERTS-1 imagery and machine processed products is highly advisable for this field of research.

LIST OF TABLES

List of Figures

DIFFERENTIATION OF SERPENTINITIC FROM NON-SERPENTINITIC ULTRAMAFIC ROCKS IN ERTS-1 MSS IMAGERY

by
William Crowley
Geologist

INTRODUCTION

The 1968 state geologic map of Maryland and all county maps covering the Maryland Piedmont lump all Ultramafic rocks into a single unit, commonly designated serpentine, serpentinite, or ultramafic rocks. Recent field work in Baltimore County has shown that it is often possible to further differentiate this single unit into two units, namely serpentinite, and non-serpentinitic ultramafic rock. In the following discussion to avoid tedious repetition of such awkward terms, these will be shortened to "serp" and "non-serp" respectively.

SCOPE

The two principal serp masses in Baltimore County, Bare Hills, and Soldiers Delight, show up in ERTS-1 MSS imagery (color composite, Oct. 11, 1972, E-1080-15192) as purplish splotches. The ultramafic rocks at Bare Hills are almost exclusively serp, but at Soldiers Delight the serp is partially surrounded by an envelope of non-serp and has a southeasterly extending tail some 15 miles long consisting only of non-serp. Purplish areas in ERTS-1 imagery define only serp. Non-serp prints out red and cannot be distinguished from adjacent non-ultramafic rocks. The reason for this distinction between serp and non-serp lies in the observation that non-serp supports a vigorous hardwood flora whereas serp generally supports only stunted Virginia Pine interspersed with dense stands of greenbriar and bare patches of rocky ground.

The distribution of serp and non-serp areas are shown in Figure 1.

APPLICATIONS

The differentiation of serp from non-serp has a number of important applications. These are discussed under the four headings listed below:

Scientific

Non-serp is almost certainly the result of reaction between serp and clastic sediments during regional metamorphism. The relative volumes and areal distribution of serp and non-serp in the Piedmont give some measure of the movement of volatiles and mobile components during metamorphism.

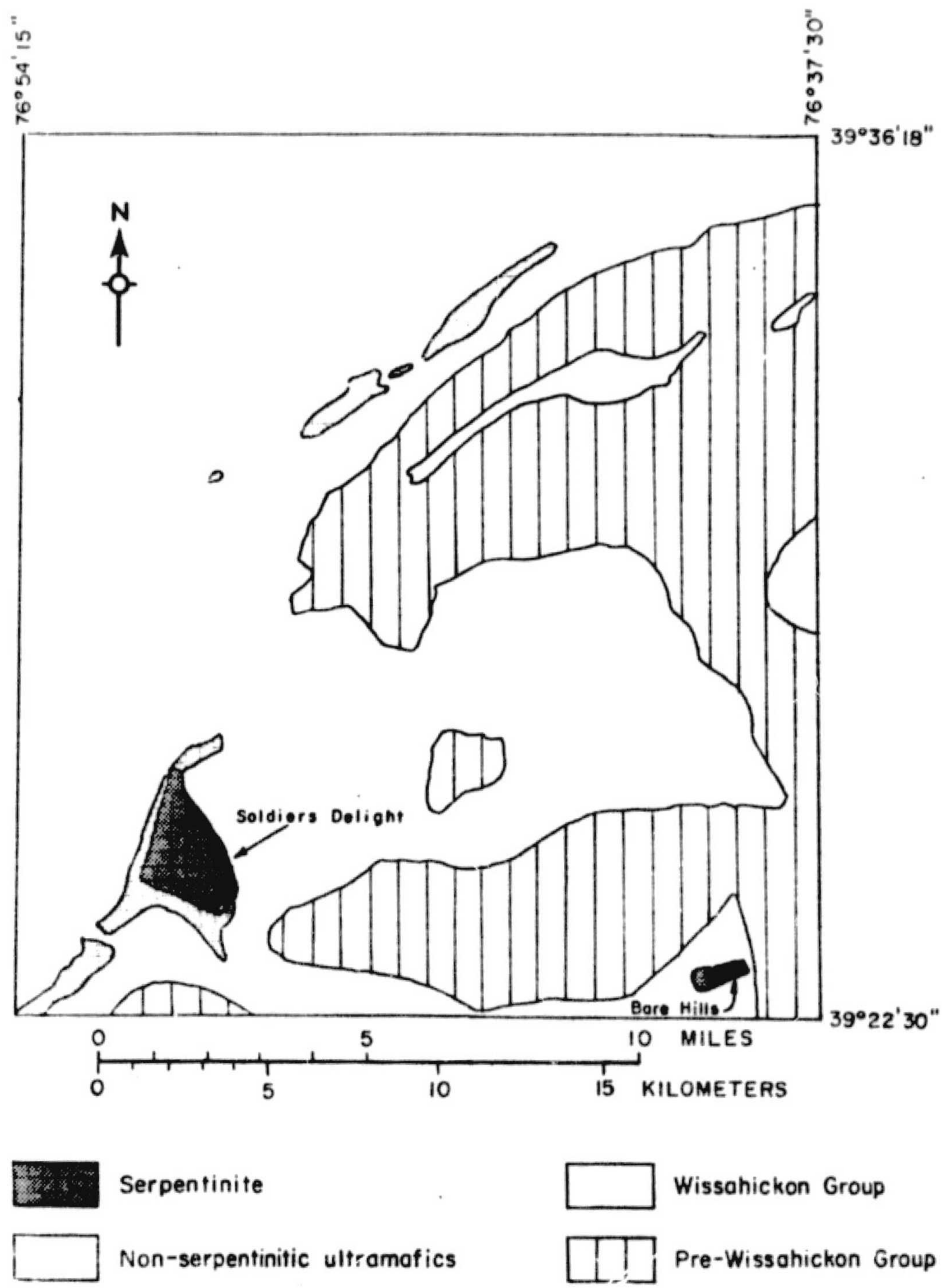
Economic

The texture and mineralogy of serp make it an ideal material for use as crushed stone. Non-serp can be quarried locally for crushed stone, but it is so commonly chloritic as to be unsuitable for this purpose.

The numerous chromite operations that once flourished in the Maryland Piedmont were confined exclusively to serp. No important chromite deposits have ever been discovered in non-serp.

Agricultural land-use

The low concentration of plant nutrients and the high concentration of such toxic elements as nickel and chromium in serp, plus the extremely thin soil cover over serp make it a very poor choice for either cultivation or grazing. Non-serp is possessed of these qualities to a considerably lesser degree, and can generally be farmed, though probably not as successfully as non-ultramafic rock.



Generalized geologic map of the Maryland Piedmont, north of Baltimore, showing the distribution of serpentinitic versus non-serpentinitic ultramafics, as determined from ERTS-1 MSS imagery and field checking

Figure 1 *Distribution of Serpentinitic and Non-Serpentinitic Ultramafic Rocks*

Non-agricultural land-use

The extremely thin soil cover over serp renders it generally unfit for extensive development. Well yields are commonly low, septic systems poorly operable, and construction requiring anything but very shallow excavation is very expensive due to the necessity of blasting. Non-serp does not pose as serious a problem in this regard, but is generally less ideal than non-ultramafic rocks.

Inspection of NASA high altitude, underflight, infrared imagery of the eastern Maryland Piedmont reveals that bedrock lithology and structure are enhanced only to the extent that land use is geologically dictated. For example, the Setters Formation,a thin, steeply dipping, highly quartzose unit, invariably underlies steep, narrow ridges covered by a thin stony soil. Such ridges are suitable neither for agriculture or grazing, nor for commercial or residential development; they are everywhere heavily forested and thus easily recognizable in infrared imagery. The Cockeysville Marble, a carbonate unit, underlies broad, fertile valleys that have been intensively developed and almost entirely deforested. The contrast between the Setters and Cockeysville is thus marked by an extreme contrast in land use. This contrast is sharply defined in infrared imagery, and can be used to map the Setters-Cockeysville contact. The land use contrast between the Cockeysville and the Wissahickon Formation, a pelitic schist unit, though locally marked, is not generally as great, and is, therefore, a less faithful guide to the contact.

Several faults are known in the Baltimore area, but none show up in infrared imagery except the Texas fault and this feature in turn apparently influences land use sufficiently to define the fault trace.

CONCLUSION

It has been demonstrated that through the use of ERTS-1 imagery it is possible to differentiate Piedmont ultramafic rocks into serpentinite and non-serpentinitic types in Baltimore County. Recent field work in Baltimore County revealed that the signature returns of serpentinitic and non-serpentinitic rocks correlates with the vegetation cover and general land use pattern. Non-serpentinitic supports a vigorous hardwood flora and some farming practices with a red signature return whereas serpentinitic rocks have stands of Virginia Pine and greenbriar with little land-use development. In Maryland Piedmont, bedrock lithology and structure are enhanced only to the extent that land use is geologically dictated. ERTS-1 high altitude, aircraft support, infrared film was used to map the Setters Formation-Cockeysville Marble contact which shows up as a high contrast in land use.

OBSERVATION OF LINEAR FEATURES IN THE MARYLAND PIEDMONT AS SHOWN ON ERTS-1 PHOTOGRAPHY AND MSS IMAGERY

by
Jonathan Edwards, Jr.
Geologist

INTRODUCTION

The ERTS-1 underflight photographs are vastly superior to conventional aerial photomosaics of equivalent areas because the ERTS photos cover a large area of the State and represent an instant of time for each photo, whereas the photomosaics are composed of many individual photos taken at various times during the day or even over a span of several days. Thus the differences in tone and contrast which are inherent in the aerial photomosaics are avoided and subtle features of possible geologic origin, masked by the tonal contrasts in the mosaic, are readily apparent in the ERTS photo.

LINEAR FEATURES DETECTION

The most obvious features seen on both the 9 x 9 prints from the MSS chips and on the underflight photos are in the Appalachian region. Possible linear alignments of fold culminations, depressions, plunging noses, and offsets in strike may be picked out.

The ERTS-1 imagery has been of little help in deciphering the geology of the western Piedmont where I have been engaged in field mapping over the past several years. Apparently the lack of distinctive differences in the lithologies has inhibited the expression of structural features in the topography. Also, the western Piedmont in many of the photos was obscured by a hazy cloudcover.

In the Piedmont region east of Westminster, Carroll County, two prominent sets of linear features can be seen. One set is comprised or two belts, about five miles apart, each trending approximately N45°E. The most westerly belt is a line of ridges formed by the Sam's Creek Metabasalt, which passes through Westminster and extends into Pennsylvania near Lineboro. The more easterly belt follows the trend of a quartzose facies of the Wissahickon Schist, formerly called the Peters Creek Formation, and extends from Finksburg, Carroll County through Greystone and Whitehall in Baltimore County. Between these two belts which trend N45°E lies the second set of linear features, which trend N20°E. These show as faint alignments of linear stream reaches, wooded ridges, and valleys. The most westerly of these linear features passes northward from Hoffman Mill to Millers, in Carroll County. According to the Geologic Map of Maryland, this linear feature would be associated with the most easterly occurrence of the Wakefield Marble. The more easterly linear features of the N20°E trend run from the vicinity of Finksburg northerly through Prettyboy Reservoir to Pennsylvania. None of these N20°E linear features have been field checked to determine the geologic reasons for them. However, Dr. George W. Fisher of the Department of Earth and Planetary Sciences, the Johns Hopkins University, pointed out that these linear features correspond to linear patterns on the U.S.G.S. open file aeromagnetic map of the Maryland Piedmont, and probably represent as yet undiscovered folds or faults in the Wissahickon Schist terrain.

CONCLUSION

The ERTS-1 underflight photography and MSS imagery can be best used as

guides in detecting subtle geologic features, such as linear alignment of fold culminations, depressions, plunging noses, and offsets in strike. Two prominent sets of linear features are detected on ERTS-1 imagery. One set is comprised of two belts trending N45°E and are composed of Sam's Creek Metabasalt (western belt) and quartzose facies of the Wissahickon Schist (eastern belt). The second set of linear features is detected between the western and eastern belt of the first set and trend N20°E. These subtle features, such as lineaments, may be of significance not only in the interpretation of regional geology, but also may have practical importance in environmental geology, such as indicating zones of high ground-water yields, mineralization, or shattered and deeply weathered bedrock.

Ground-truth verification and detail geological mapping has not been made but ERTS-1 imagery has supplied an important first step toward accurate geological mapping.

MARYLAND CHESAPEAKE BAY BEACHES-GENERAL DISTRIBUTION AND CLASSIFICATION

by
Randall T. Kerhin and Turbit H. Slaughter

INTRODUCTION

The purpose of this report is to map the sand beaches of Maryland's Chesapeake Bay through the use of ERTS-1 MSS imagery and aircraft support underflight data. The period covered for the imagery is October, 1972 and for the aircraft support, August 22, 1972. The report is presented in two sections. The first section is an analysis of imagery and underflight interpretation to the beach distribution of Chesapeake Bay. The second section is a classification of beach types in the Bay and a yearly comparison of seasonal beach trends at two separate locations in the Bay.

The U.S. Army Corps of Engineers (1966) define the beach as "the zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material of physiographic form or to the line of permanent vegetation. A beach included the foreshore and backshore. The foreshore is that part of the shore lying between the crest of the seaward berm or upper limit of wave wash at high tide and the ordinary low water mark. The backshore is that zone of the shore of beach lying between the foreshore and the coastline and acted upon by waves only during severe storms."

This report is concerned with mapping of the Bay's sand beaches.

GEOLOGY OF THE BAY

The Maryland Chesapeake Bay lies within the Coastal Plain Province. Sediments of Cretaceous, Tertiary, and Quaternary age crop out along the shore. The Quaternary sediments outcrop over the greatest area, the Tertiary next, and the Cretaceous least. The Quaternary sediments are gravels, sands, silts, and clay, and mixtures of these form the shoreline outcrop of most of the Eastern Shore; the Potomac and Patuxent Rivers on the Western Shore; the Bay front of St. Mary's County; and much of the Bay front of Anne Arundel, Baltimore, and Harford Counties. The Tertiary sediments which are sands, clays, silt, greensand, and diatomaceus earth crop out along the Potomac River in Prince Georges and Charles Counties, the Patuxent River in St. Mary's County, and the bayside of Calvert and southern Anne Arundel Counties. Cretaceous sediments composed of gravel, sand, silt, and clay crop out along the upper Potomac River in Prince Georges County, the Bay front in northern Anne Arundel and Harford Counties, the upper part of Kent County and parts of Cecil County. Quantitatively along the Bay shore silty sands predominate. The most resistant to erosion are the stiff Cretaceous clays of the upper Bay and the highly consolidated, silty clays of the Tertiary which outcrop along the Calvert Cliffs of Calvert County. The most easily eroded sediments are those of the Quaternary lowlands and undifferentiated lower Eastern Shore outcrops.

BEACH DISTRIBUTION

Objectives and Methodology

It is generally recognized that beach widths and erosion or accretion are below the resolution limits of the ERTS-1 imagery, particularly for beaches in Chesapeake Bay. A quick-look analysis of the imagery reveals that

beach and non-beach reaches of shoreline are detectable and can be mapped on a scale of 1:1,000,000. To map the distribution of beaches in Chesapeake Bay, direct overlays of 9 x 9 bulk processed positive transparencies were constructed using manual image interpretation of the beach signature. A white signature return at the land/water interface was interpreted and mapped as beach features. This is not the first attempt to map the beach distribution of Chesapeake Bay. The U.S. Soil Conservation Service has mapped the coastal beaches as a soil type in the county surveys. The objective in this analysis is not to duplicate their effort but to evaluate the effectiveness of ERTS-1 to detect small-scale beach features with strict manual image interpretation. In some instances, the soil surveys were used for ground-truth verification in remote areas of Chesapeake Bay.

Multispectral Selection

The first step in the analysis was to scan different spectral bands and time periods to determine the optimum imagery for beach distribution mapping. The general condition was to evaluate and select a spectral band that displays high contrast at the land/water interface. Evaluation of MSS band 5 (0.6-0.7mm) MSS band 7 (0.8-1.1mm), and MSS color composite bands 5, 6, and 7 was made prior to mapping. Beach features from MSS band 5 were difficult to interpret because of the signature of nearshore turbidity. Image interpretation of MSS band 7 proved adequate for beach identification because of the high contrast at the land/water interface. Nearshore turbidity is a darker signature which tends to isolate the white beach signature. The only problem encountered was the lack of high contrast between some beach and interior coastline signatures which were relatively close in grey scale comparisons. The most suitable imagery for beach distribution mapping is the color composite. The

color composite tends to isolate the beach zone at the white end of the grey scale with darker signature returns for the water and interior coastline interfaces. A problem common to all imagery in detection of small-scale beach features is the interference of scan lines. Color composite recorded the least scan line interference and with proper processing, the scan line problem may be alleviated.

The next phase of the analysis was selection of a time period best suited for beach identification. Two time periods were evaluated; October, 1972 and January, 1973. Selection of these two time periods was based on the most complete imagery coverage of Chesapeake Bay. Criteria for selection was simply which time period isolated the beach zone the best as detected by manual image interpretation. October, 1972 was selected as the optimum time period for two reasons:-

1) October, 1972 (E-1081-1544, E-1079-1533) time period has a high contrast of interior coastline to the beach zone because of the vegetation signature. The interior coastline signature is lacking in the January, 1973 imagery due to the winter time period.

2) Beach and nearshore ice was identified in the January, 1973 imagery and verified by aircraft support and ground-truth. The ice features returned a white signature in the imagery which is easily misinterpreted as beach features.

The actual mapping procedure involved constructing a direct overlay on the positive transparencies at a scale of 1:1,000,000. Registration was maintained by the four diagonal tick marks imprinted on the imagery. With the aid of a Bausch and Lomb binocular microscope at a 0.7 magnification

beach features were identified and mapped directly on the overlay. To supplement the lower Eastern Shore, MSS band 7 December 03, 1972 (E-1133-15144) was also used in the mapping. Mapping at this scale on a direct overlay represents the general location of beach systems and is not applicable to quantitatively determination of shoreline lengths of beach and non-beach.

Multispectral Beach Distribution

Figure 2 represents the beach distribution as mapped from ERTS-1 color composite imagery. Distribution of the beach systems appear concentrated in the lower section of Maryland's Chesapeake Bay particularly Calvert and St. Mary's counties on the western shore and Dorchester and Somerset counties on the eastern shore.

The two areas of major beach distribution represent two distinct types of coastal environments. St. Mary's and Calvert Counties coastline varies from small low-lying banks to high vertical cliffs. A strong vegetation signature is evident in the imagery for the interior coastline which offers good contrast with the lighter beach zone signature. Dorchester and Somerset counties contain major wetland marshes which are inundated during the diurnal tidal cycle. The return signature of the wetlands is dark which tends to isolate the white signature of the beach zone. Anderson (1973) reported that the high moisture content of the marsh areas is responsible for the dark signature. Both major concentrations produce good contrast signatures which allow for manual image interpretation. A second factor which is apparent in both areas is the linearity of the beach systems with the coastline. In St. Mary's and Calvert counties, the beaches are contiguous with the shoreline as are the beaches in Somerset County especially Deal and Janes Islands. The linearity (continuous length of beach) is greater for St. Mary and Calvert

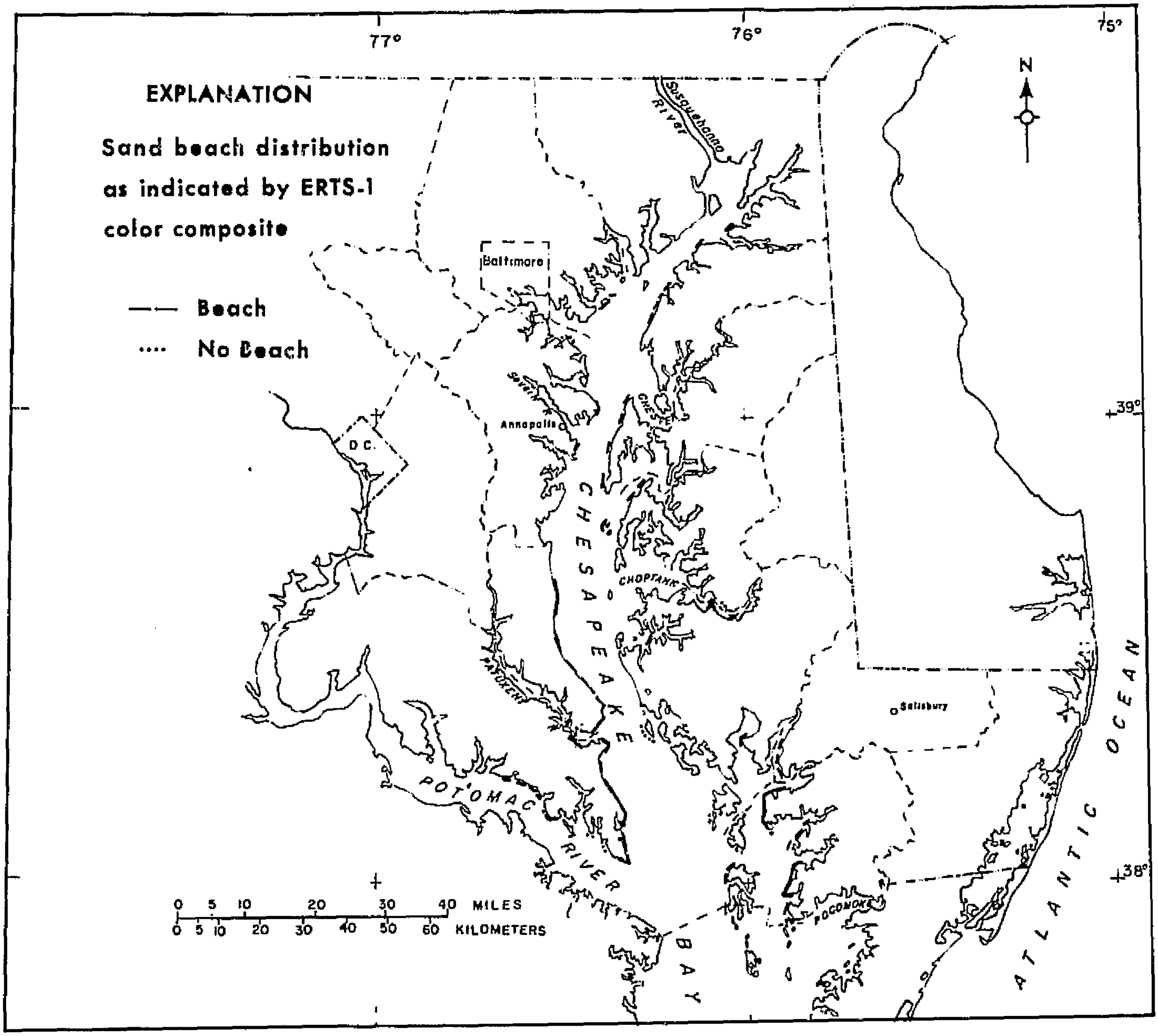


Figure 2 *Beach Distribution Map as Determined for ERTS-1 Color Composite Imagery Scale 1:1,000,000*

counties than for the lower Eastern Shore but the contrast of the land/water interface for St. Mary and Calvert counties is less. Manual image interpretation of a beach signature is dependent on two factors; the contrast of the land/water interface and the linearity of the beach system. The exact degree of contrast or linearity of a beach system was not determinable from this analysis. As evident in the scatter beach distribution of the upper Chesapeake Bay, small, linear, pocket-type beaches are mappable but occur in high contrast environments such as sub-estuaries and wetlands. In coastal environment that returns a high contrast signature (wetlands and sub-estuaries), a smaller beach length is mappable, but if the contrast is low (red signature from vegetative cover), the linearity of the beach system becomes an important factor.

Aircraft Support Beach Distribution

To compare the beach distribution map as manually interpreted from ERTS-1 imagery, a second beach distribution map was constructed using high-altitude aircraft support color infrared photography dated August 22, 1972. The map was prepared at a scale of 1:250,000 using the direct overlay method. Ground-truth observations and the Soil Conservation Survey maps aided in correction and verification of the aircraft support distribution map. Figure 3, represents the combined ERTS-1 and A/C beach distribution maps. The most obvious feature of the combined distribution map is the greater extent of beach features mapped using aircraft support in the rivers and sub-estuaries of Chesapeake Bay. For example, along the north shore of the Potomac River good correlation exists between ERTS-1 and aircraft support for the beach systems from Point Lookout to Herring Creek. Westward from Herring Creek (upstream) manual image interpretation of ERTS-1 fails to detect any beach

signatures which are detectable by aircraft. There are two basic changes in the coastal environment which may account for the lack of ERTS-1 to aircraft support agreement. Near the mouth of the Potomac River, sub-estuaries and tidal wetlands are the dominant coastal environment. Progressing upstream the coastal environments change to an upland type of environment with upland vegetation. This change in the type of environment alters the degree of contrast of the coastline to beach signature. The higher contrast scenes of the lower Potomac River tends to isolate the white beach signature which allows for easier manual interpretation. The second change deals with the physical characteristics of the beach systems. The beach system changes from linear beaches contiguous with the coastline as in Cornfield Harbor on the Potomac River, St. Mary's County, to small pocket beaches nestled in small coastal embayments. The beach signature of the smaller scale beach features coupled with a lower contrast scene prove difficult to identify. These two subtle changes in the physical environment generally account for the lack of correlation between ERTS-1 and aircraft support beach distribution.

Conditions of Misinterpreted Beach Signature

Though there is a greater distribution of beaches in Chesapeake Bay than detected by ERTS-1; in areas where manual interpretation of ERTS-1 has mapped a beach system, aircraft support and ground-truth generally verified the existence of a beach system. There are exceptions to the good correlation of actual beach distribution to ERTS-1 and aircraft support beach distribution. A beach system was detected from ERTS-1 for Susquehanna Point in the Little Choptank River, Dorchester County.

Through aircraft support and ground-truth, the white signature identified on ERTS-1 proved to be a nearshore turbidity signature resulting from erosion of the immediate shoreline. Another hazard of interpreting a white signature as a beach system is evident for the area between Cove Point and Camp Conoy in Calvert County. Both ERTS-1 and aircraft support interpretation identified a beach system for this area. Low-level aircraft support and ground-truth show that a beach system does not exist and t identified white signature is actually the barren near vertical cliffs of the Miocene Calvert Formation (Figure 4). A third hazard is evident for St. Georges Island in the Potomac River, St. Mary's County. A white signature was identified from both ERTS-1 and aircraft support as a beach system is not evident. The white signature return in this instance is fill material behind a wooden bulkhead without an existing beach system (Figure 5). A fourth hazard is misinterpretation of shoreline erosion control structures (white stone riprap) at the land/water interface. At Kent Point on Kent Island Queen Annes County, the land/water interface is covered with a white stone riprap structure. These examples represent typical hazards in interpreting a white signature from ERTS-1 and aircraft support as a beach system without ground truth verification. Table 1 lists the areas where manual image interpretation of a white signature as a beach system proved to be a physical condition other than a beach system. To summarize, four conditions were identified as misinterpretation of a beach signature 1) fill material behind a bulkhead, 2) near vertical cliffs without vegetative cover, 3) nearshore turbidity, and 4) shoreline erosion control structures.

Figure 4 Vertical Cliffs of Miocene Calvert Formation Returns a White Signature on ERTS-1 Imagery which is Misinterpreted for a Beach System

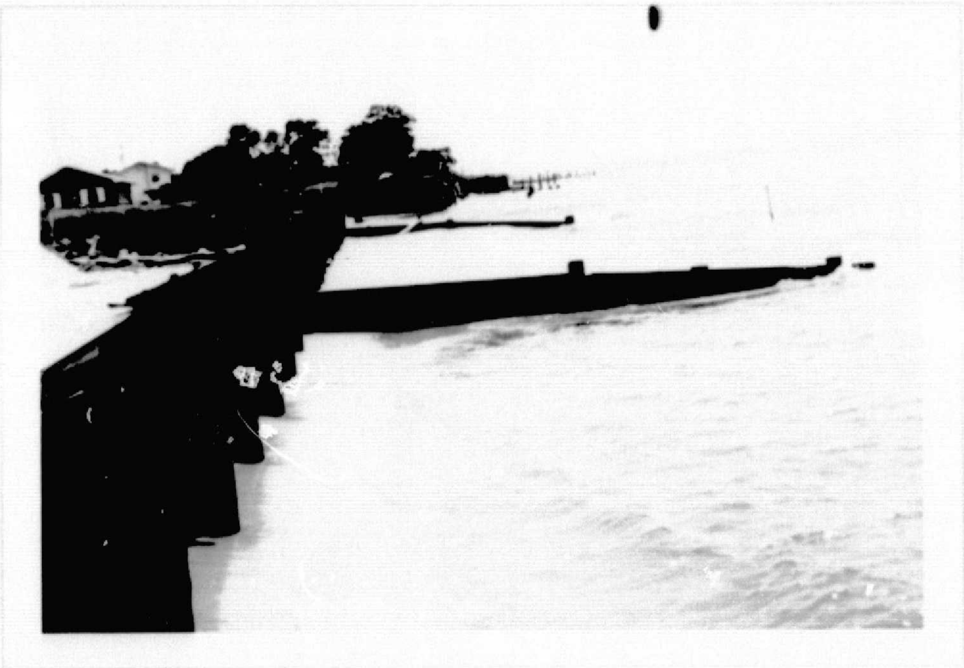


Figure 5 Fill Material Behind a Bulkhead can be Mistaken for a White Beach Signature on ERTS-1 Imagery

TABLE 1

Areas of Misinterpretation of the Beach Signature from ERTS-1 and Aircraft Support

Area	County	BEACH SIGNATURE IDENTIFIED FROM ERTS-1	A/C	GROUND TRUTH
Cobb Island	Charles	No	Yes	Fill material behind bulkhead
St. George Is.	St. Mary's	Yes	Yes	Fill material behind bulkhead
Rocky Point	Calvert	Yes	Yes	Vertical cliff-no vegetation
Greenbury Point	Anne Arundel	No	Yes	Fill Material behind bulkhead
Chesapeake Beach	Calvert	No	Yes	Fill Material behind bulkhead
Bodkin Point	Anne Arundel	No	Yes	Vertical cliff-no vegetation
Ft. Smallwood	Anne Arundel	Yes	Yes	Fill material behind bulkhead
Black Marsh	Baltimore	No	Yes	Fill material behind bulkhead
Grove Neck	Cecil	Yes	No	Vertical cliff-no vegetation
Worton Point	Kent	No	Yes	Vertical cliff-no vegetation
Love Point	Queen Annes	Yes	Yes	Fill material behind bulkhead, Vertical Cliff
Kent Point	Queen Annes	No	Yes	Shoreline erosion control structures
Blackwalnut Point	Talbot	No	Yes	Shoreline erosion control structures
Susquehanna Point	Dorchester	Yes	No	Nearshore turbidity

Comparison of Beach Length To Total Shoreline Length

Although it was stated earlier that quantitative beach lengths could not be accurately made, estimation of beach lengths were calculated for purposes of comparing ERTS-1 to aircraft support interpretations. Using the base map scale of 1:250,000, estimation of length of beach for each of the tidewater counties were calculated and converted to kilometer units. A comparability index was devised for ERTS-1 to aircraft support beach length estimates along with comparison of ERTS-1 and aircraft support to total shoreline of each of the tidewater counties. Table 2 shows the beach length estimates and the comparability indices.

Chesapeake Tidewater Maryland represents a total shoreline length of 6128 km of which 155 km of beach length were interpreted from ERTS-1 imagery and 510 km of beach length from aircraft support analysis. Three percent of the total shoreline has some type of beach system detectable on ERTS-1 imagery. As detected from aircraft support interpretaion, 8% of the total shoreline length of tidewater Maryland has a beach system. The comparability index (ERTS-1/aircraft support) was calculated at 30 or a ratio of 1:3. This translates to every kilometer of beach length detected on ERTS-1 imagery, 3 kilometers are detected on aircraft support photography. The comparability indices for the western and eastern shores are 26 and 34 respectively, which is approximately the 1:3 ratio of detectability. Somerset County has an index of comparability of 84 which translates to 42 km of ERTS-1 beach identification an 48 km of aircraft support identification. Calvert County on the western shore has an index of 33 or 25 km of ERTS-1 beach identification to 42 km of aircraft support identification. Somerset and Calvert Counties display good contrast scenes at the land/water interface along with excellent linear

beach systems. This brief analysis reaffirms the earlier conclusion that the contrast at the land/water interface and the linearity of the beach systems are important factors in multispectral analysis of the beach signature.

Table 2

Beach Length Estimates and Comparability Indices

	KILOMETERS				COMPARABILITY INDICES		
Counties	ERTS-1	RB57	Total		Total-% ERTS-1	Beach RB57	% Beach ERTS/RB57
Cecil	1.9	14.8	320		.60	4.6	13.0
Kent	8.4	40.0	432		1.90	9.2	21.0
Queen Annes	9.3	49.5	539		1.80	9.5	19.4
Talbot	8.4	36.6	712		1.10	5.1	22.8
Dorchester	12.8	37.1	796.8		1.60	4.6	34.5
Somerset	40.9	48.6	990		4.10	5.5	84.2
Wicomico	3.0	11.5	142.4		2.20	10.8	27.0
Subtotal	85.1	247.6	3902.4	Ave.	2.1	6.3	34.3
Harford	-	24.9	224		-	11.1	-
Baltimore	2.5	15.3	334.4		.80	4.6	16.6
Anne Arundel	3.2	48.0	670.4		.40	7.1	6.7
Calvert	24.9	42.8	228		10.9	19.0	58.2
St. Mary's	38.0	91.5	475.2		8.0	19.1	41.9
Charles	-	37.6	292.8		-	12.9	-
Subtotal	69.1	260.4	2225.6	Ave.	3.1	11.7	26.8
TOTALS	154.2	508.1	6128	Ave.	2.5	8.2	30.0

CLASSIFICATION OF BEACHES

The Bay's beaches are divided into a) broad and b) narrow types. Broad beaches are hereby defined as having a continuously existing backshore width greater than 5 meters. Figure 6 is an example of a broad beach. Narrow beaches are hereby defined as having a backshore that varies from 0 to 5 m. Figure 7 is an example of a narrow beach. Maryland's sand beaches are principally the narrow type.

As described in the beach distribution section of this report and through ground truth observations we can now break down the mapping procedure into one of classification and distribution of the two major types.

The broad beach type is mappable from ERTS-1 imagery along with other narrow beach types.

The width of foreshore, which is part of the beach profile, will vary upon the foreshore slope and the tidal range. Based on an average tidal range for the Bay of 45 cm, and foreshore slope of 6 to 10 degrees, the shoreface width will vary on the average from 2.5 to 4.5 m. Maryland's tidal range is designated as microtidal, 36 cm to 64 cm.

The following is a tabulation for selected sites from the southern end of the Bay to its head of the average tidal range.

Location	County	Tidal Range in Centimeters
Point Lookout	St. Mary's	36 cm
Janes Island Light	Somerset	55 cm
Bloody Point Light	Queen Annes	34 cm
Tolchester Beach	Kent	36 cm
Fishing Battery Light	Cecil	64 cm

Figure 6   Example of a Broad Beach at St. Clarence Creek, St. Mary's County

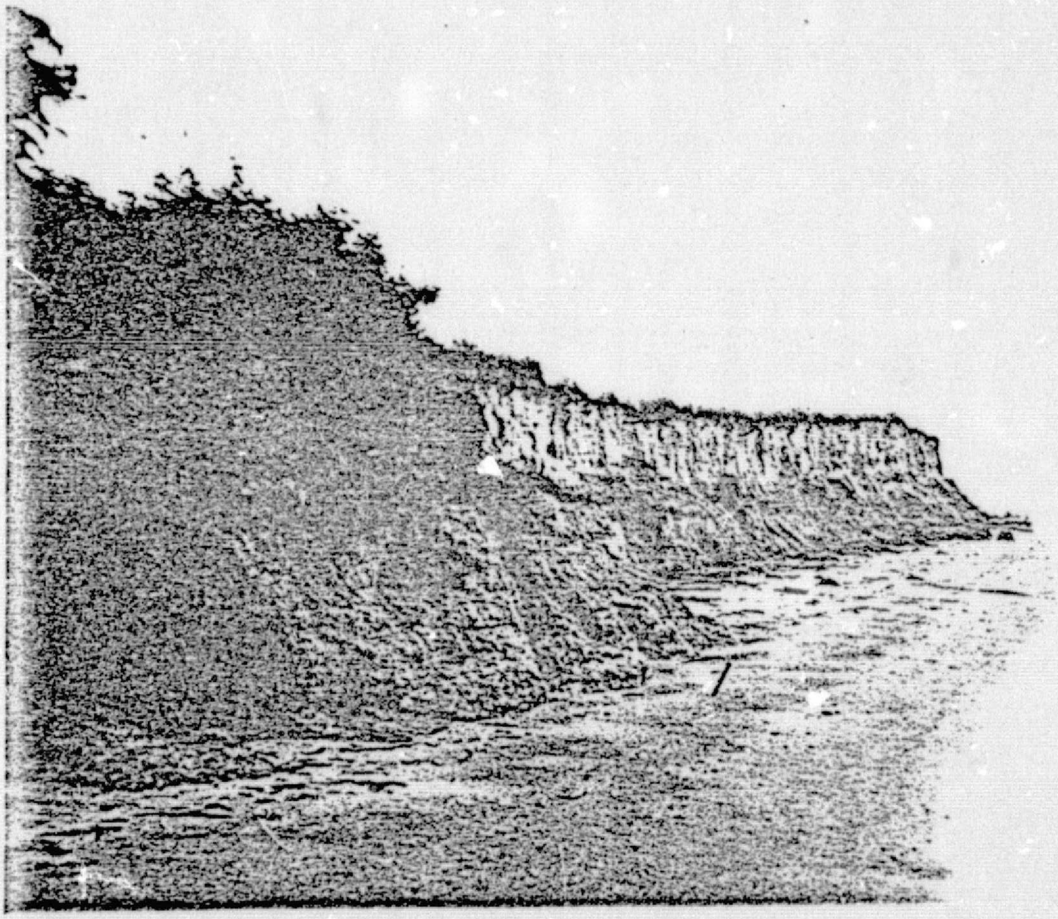


Figure 7   A Narrow Beach Located along Eastern Neck Island, Kent County

Although the tidal ranges in Chesapeake Bay are classified microtidal, storm surge tidal heights have reached 2.5 m or more as recorded during the August, 1933 storm. The significance of storm surge tidal heights are more important to narrow beaches and their limited backshore widths. During storm conditions the backshore of a narrow beach is entirely exposed to active high energy storm waves and offers little or no shoreline erosion protection.

Broad Beaches

All of Maryland's broad beaches which are located on the western shore are discernable from ERTS-1 imagery (Figure 3). The areas are hereby listed by County and length of beach.

	(Meters)	(Km)
Anne Arundel County		
Sandy Point State Park	1200	
East of Blackwalnut Creek	600	
	1800	1.76
Calvert County		
Plum Point	600	
Western Shores	1170	
Flag Ponds	420	
Cove Point	1500	
Drum Point	1050	
	4740	4.8
St. Mary's County		
St. Clarence Creek area	1560	
Point-No-Point	654	
Deep Creek Area	1170	
Piney Point Beach	1500	
Herring Creek barrier	714	
beach	5598	5.6
Total	12,138 =	12.1

A total of 3.2 km of beach was mapped in Anne Arundel County by ERTS-1 imagery, thus broad beach length is 55% of the total mapped. Calvert County had a total of 25 km of imagery mapped beaches of which 19.2% are broad beaches. St. Mary's County has the greatest length of beach mapped

by imagery 38.5 km of which 14.5% are broad beaches. Thus of a total of 70 km of imagery mapped beaches for the three counties, 18% are broad beaches.

Anne Arundel County

1. Sandy Point State Park - This park beach is not totally natural because of the ferry slip jetties and man-made improvements. Historically over the period 1844-1942 Sandy Point had undergone erosion on the Bay side although the point proper accreted. After the construction of the northern ferry slip jetty in the early thirties, the Bay side beach began to stabilize but not accrete. The park beach on the Bay side has been stabilized since the park was opened in 1952. Bay side beach width is over 30 m and length of beach is about 1,220 m. Mean annual tidal range is 25 cm. Predominant littoral drift direction is southeast toward the point and the southwest toward the ferry slip jetty. Inspection of ERTS-1 underflights August 11, September 23, October 20, 1972, and February 12, 1973, all show the predominant drift pattern, however, the flight of November 1, 1973 shows the drift direction to be reversed. Reversed drift direction can be expected due to localized weather conditions.

2. East of Blackwalnut Creek - From Tolly Point at the south shore entrance to Severn River south to the entrance to Fishing Creek the shoreline is bowed westward into a broad embayment. The apex of the embayment is eastward of Blackwalnut and Oyster Creeks. Between 1844 and 1942 this area accreted 10.7 acres. The area was 360 m in length and had a maximum width of 75 m. Subsequent erosion has reduced the beach area near the entrance to Oyster Creek, but the beach area east of Blackwalnut Creek has been maintained. Today this beach area is about 600 m long and 30 m wide.

Calvert County

3. Plum Point - Historically the beach area south of Plum Point Creek has accreted linearly a maximum of 39m over the period of 1847-1944. The length of beach is about 600m. Mean annual tide range is 27 cm. This beach has been monitored since November, 1970 and during that time beach width has varied as much as 6m but no net erosion or accretion rate has been recorded. Average beach width is 9m.

Predominant littoral drift is southward, however, the overall disposition of beach width remains stable.

4. Western Shores - Western Shores is located 1.9 km south of Kenwood Beach. Historically over the period 1847-1945 this area of shoreline has remained stable. Comparison of one of the earliest aerial photographs, April, 1938 to ERTS-1 underflight IR flight of November 1, 1973 essentially shows little difference in beach width or length of accreted beach area. An intermediate black and white photo of 1964 shows some change in width of beach, but it is possible that man played a part in the change through artificial beach adjustment. The beach is about 1170m long with a maximum width of 45m in its central portion averaging about 21m. Mean annual tidal range is 30 cm. Predominant littoral drift is southward. The bars and troughs since 1938 have changed frequently in number and location, however, the total system has remained essentially the same.

5. Flag Ponds - Flag Ponds is a brackish ponded area formed by the southerly migration of beach ridges located immediately south of Long Beach. The area is about 1350m long by 420m wide. Historically the southern beach ridges migrated toward the south over the period 1847-1945 a distance of 450m at the rate of 5.1m per year. Over the period 1945-1973 the

southerly migration rate was 9m per year. The beach on the Bay side has undergone erosion over the period 1847-1945, a maximum of 135m .

In about 1969 a recurved spit formed at the northern end of the Flag Ponds area. ERTS-1 flight data was used by Kerhin (1973) to trace its migratory pattern to the south.

Continued migration and growth of the southern extension of this vast sand beach area is dependent on the continued existence of an uninterrupted beach line on the Bay side.

6. Cove Point - Cove Point is the largest accretionary area of Maryland's Chesapeake Bay. Over the period 1848-1944 the south shore of Cove Point accreted approximately 60 acres building out linearly a maximum of 150m and approximately 1.6km in length. Today the area is covered by a summer cottage development. ERTS-1 underflight dated October 20, 1972 shows that the southern two thirds of south Cove Point has continued to accrete since 1944 at a maximum rate of 1.5m per year. This rate is comparable to the long term 1848-1944 rate.

7. Drum Point - Drum Point historically has accreted since 1848. The point itself has migrated 120m south the eastern Bay's Shoreline accretional area extends 600m northward and the Patuxent River side extends 450m northwest. The Bay side beach width ranges from 22.5m to 75m and the Patuxent River side averages about 30m width.

St. Mary's County

8. St. Clarence Creek - St. Clarence Creek area is composed of three, finger prong projections, all tidally connected. There is no active bay inlet into the creek. Between 1848 and 1942 the land separating the creek from

the Bay receded from 150 to 210m . Today a barrier beach about 1100m long separates the creek from the Bay averaging about 45m in width. Maximum sand beach width according to ERTS-1 flight data of May 17, 1973 is about 30m . Overall length of the beach area is 1560m . The volume of littoral drift is apparently great enough to maintain the barrier beach area as it recedes west, preventing an opening from existing. Predominant drift direction is southward toward Point-No-Point.

9. Point-No-Point - Historically Point-No-Point accreted 12.8 acres over the period 1848-1942. The point built out eastward a maximum of 150m , and extended a length of 540m . According to ERTS-1 flight May 17, 1973 the size of the area was 141m by 654m . Old beach ridges are visible. The area is undeveloped.

10. Deep Creek - The entrance shoreline to Deep Creek which is about 1350m south of Point Look-in accreted a former 1848 shallow, shaped shoreline eastward 180m , creating a straight shoreline. T. e length of the accreted area in 1942 was 900m . The area of accretion was 18.4 acres, however, this does not totally represent sand. The northern half is about 6 acres sand, the southern half 7.2 acres sand, making a beach area of about 13 acres. ERTS-1 film of May 17, 1973 showed the length to be 1170m and maximum accretion width measured on the south side to be 210m showing an increase over the 1942 dimensions.

11. Piney Point Beach - Piney Point Beach about one mile in length over the period 1868-1943 showed little or no change. Today the beach is a summer cottage development with a backshore beach reaching a maximum width of about 22.5m . This shown in ERTS-1 flight of May 17, 1973.

12. Herring Creek Barrier Beach - Herring Creek has had a varied existence of inlets. In 1868 there was one inlet about in the same location as the present jettied entrance, with a barrier beach length of 714m and width of near 60m . In 1943 there were three inlets with the 1868 inlet being closed. By 1952 there was one inlet at the southern end of the barrier beach which had a maximum width of 30m . The U.S. Army Corps of Engineers in 1961 completed dredging a channel through this opening and erected two stone jetties to protect the channel. Net littoral drift direction is southward in this area causing an accumulation on the northside of the north jetty. Construction of numerous small groins along the McKay Beach area to the north may have caused a diminishing southerly flow of littoral drift towards Herring Creek. As a consequence, the north end of the barrier beach thinned by May 21, 1964 to about 18m. ERTS-1 underflight data of May 17, 1973 showed the northern end to be about 6m and the southern end 70.5m wide. It may be predicted that an opening will be created at the northern end, which will diminish the overall width of the barrier beach.

Narrow Beaches

Narrow beaches as defined, are by far the predominant beach type in the Bay. In some instances these beaches have a varied occurrence of width and length while other areas seem to maintain a fairly uniform appearance throughout the year.

The phenomena of seasonal changes in direction of littoral transport and resulting beach width has been described in a paper presented at the symposium held by Goddard Space Flight Center, March 5, 1973 (Slaughter, 1973).

To illustrate the variance of beach length an attempt is made to compare

two separate areas of different geologic age and geographic location covering a period of almost a year. Two Bay areas were selected for comparison of length of beaches for the period of August 22, 1972 to May 17, 1973 utilizing ERTS-1 high and low level aircraft support photography film. The areas are the Bay side of Kent Island, Queen Annes County, and from the Chesapeake Beach to Cove Point, on the Bay in Calvert County. These areas represent the eastern and western shores of the Bay that have relatively straight shorelines. The length of these areas are 26.4 km and 36 km respectively. Kent Island Bay front faces west thus the prevailing northwest and southwest winds vent their force on the shore most of the year. The Calvert Cliffs facing east are in the lee of these winds, however, winter northeasterly winds and summer southerly winds make their influence felt. Kent Island is composed of Quaternary sediments ranging from sand to clay cropping out in vertical vegetationless banks ranging in heights to 6 m. Silty sands are predominant.

The Calvert Cliffs are predominantly near vertical, bare of vegetation, have a maximum range of 18 m to 30 m height. The basal sediments at the shoreline are Tertiary age, but are overlain by a veneer of Quaternary silty sands. In some instances the Quaternary sediments outcrop along the shore as post-Tertiary eroded valley fill. These areas generally have a high percentage of sand which ultimately becomes part of the beach supply. The basal Tertiary formations are of the Miocene series. The Calvert Formation which is basal in the series outcrops from Chesapeake Beach, the northern end of Calvert County to Parkers Creek the center of the Calvert Cliffs. The Calvert Formation along the Bay beaches is highly consolidated sandy clay and shell beds. The southern half of the cliff area is principally Choptank Formation which is a fine grained sand to a clay silt with shell beds.

The sandy unconsolidated nature of the Kent Island banks allow erosion up to 3.6m per year. The stiff, consolidated nature of the Calvert Cliffs resists erosion thus it has a recession rate of 30cm to 60cm per year.

The following tabulation lists the dates of the ERTS-1 film and length of beach for the periods measured. Both broad and narrow beaches are included in this tabulation.

Flight Altitude	Film Data	Beach Length in Kilometers	
		Kent Island	Calvert Cliffs
High	August 22, 1972	16.5	29.6
Low	September 23, 1972	13.6	-
Low	October 21, 1972	-	24.4
High	December 3, 1972	16.5	-
High	January 26, 1973	-	14.4
Low	March 23, 1973	16.5	14.7
High	April 29, 1973	13.6	16.8
Low	May 17, 1973	13.6	25.6

This tabulation presents an interesting problem of interpretation of data. Some of the more obvious photo interpretive reasons for the variance of beach lengths are time of day of the flight that would influence shadows relative to height of bank. This is especially true along Calvert Cliffs with banks that reach 24m or more in height. A high altitude flight would reflect the slope of the bank as beach. The time of flight relative to tide height would exclude some beaches at high tide. Some protected banks have nonvegetated fill behind the bulkhead, which at high altitude tends to reflect as a beach when in reality there is no beach in front of the protective structure. These and other misinterpretations are described in the Beach Distribution section.

Between August 22, 1972 and May 17, 1973 Kent Island beach length according to ERTS-1 underflight film varied from 16.5m to 13.6m . An average of

15.2m is believed to be a reasonable consistent length of beach. The Calvert Cliffs beach for the same period of time ranged from 29.6 to 14.4m, averaging 20.9m. Thus of their total length of shoreline, Kent Island has 58 percent and Calvert Cliffs 58 percentof beach.

Aside from the mechanics of aerial photo interpretation, the range of beach length of Kent Island and Calvert Cliffs during a year will be dependent on prevailing and seasonal climatic conditions, and the supply of littoral material from eroding banks and the nearshore.

The percentage of beach shoreline to the total length of shoreline for two areas is relatively high in comparison to the total beach for each county. This comparison has been already described.

Table 2 (3-15) lists the counties and their respective ERTS-1 imagery and aircraft support shoreline lengths. Although an actual physical inspection, if synoptically possible, would show a different length of broad and narrow beaches, it is believed that the lengths as defined through ERTS-1 imagery and aircraft support photography is representative of Maryland's Chesapeake Bay.

SUMMARY

The effectiveness of ERTS-1 multispectral imagery to detect small-scaled beach features with strict manual image interpretation is dependent on two factors; the contrast at the land/water interface and the linearity of the beach system. High contrast-short beach system (barrier beach across a sub-estuary) are as detectable on ERTS-1 imagery as are low contrast/long beach systems (St. Mary's County). The imagery most applicable to beach signature detection is MSS band 7 and MSS color composite. A major problem associated with the imagery and interpretation of small-scaled beach features is the interference of scan lines. Machine processing and beach signature isolation techniques may help to alleviate this problem but care must be taken in any analysis of small-scaled beach features.

Comparative analysis of ERTS-1 and aircraft support beach distribution indicate that 3% (155.2 km) of total shoreline is beach as detectable from ERTS-1 and 8% (507.2 km) from aircraft support for the entire Chesapeake Tidewater Maryland. The comparability index of ERTS-1 to aircraft support is approximately a 1 to 3 ratio or 30% of the beaches mapped by aircraft support are mappable from ERTS-1 imagery. The highest comparability index recorded was for Somerset County where a high contrast environment and linear beaches are dominant.

Through ground truth verification, four misinterpretations are recognized. The most common condition for misinterpretation of the beach signature is fill material behind a bulkhead. The other misinterpretations are nearshore turbidity, vertical, barren sedimentary cliffs, and shoreline erosion control structures.

Based on ERTS-1 imagery and aircraft support data, beaches of Chesapeake

Bay are classified as broad and narrow beaches. The predominant type is a narrow beach which exists throughout the Bay coastal zone while the broad beaches are confined to the western shore. Broad beach accounts for 47 km of beach length and dominate in Calvert and St. Mary's counties. A detailed study of two narrow beach systems along Kent Island on the eastern shore and Calvert Cliffs on the western shore shows that there are variances of beach length caused by photointerpretation techniques and seasonal and climatic changes. In addition, this detailed study showed that high altitude flights should be supplemented by low altitude flights and by ground-truth corrections.

ERTS-1 imagery analysis of the beach distribution and classification provided the first step in inventoring the major beach systems of Chesapeake Bay. Verification of ERTS-1 interpretation was done with aircraft support and selected ground-truth observations. With the use of ERTS-1 imagery, actual ground-truth mapping is not needed for the major beach systems and ground-truth observations can be concentrated in areas of questionable interpretation.

THE RELATIONSHIP OF THE NEARSHORE LONGSHORE BAR AND SAND WAVES AT OCEAN CITY, MARYLAND

by
Turbit H. Slaughter
Geologist

INTRODUCTION

The Baltimore District Office of the U.S. Army Corps of Engineers in one of their recent reports have published data on shoreline erosional-depositional history and offshore depths to the 10 meter contour (1972). This report correlates data at 37 profile stations ranging from 213 m to 573 m apart between the Ocean City inlet and the Maryland-Delaware line for the years, 1850, 1929, 1949, and 1965.

The purpose of this report is to relate the erosional-depositional history of Ocean City's Atlantic Coast to the offshore bar and beach forms. Utilizing U.S. Army Corps of Engineers data, it is possible to trace erosional-depositional history for 1850, 1929, 1947, and 1965. An attempt is made to correlate 1965 bar location to present locations by interpretation of ERTS-1 color IR underflight film and the relationship of the bar to beach structural forms.

SHORELINE EROSIONAL-DEPOSITIONAL HISTORY

Between 1850 and 1929, net erosion rate was 0.82 m per year, for the area between the inlet and the Maryland-Delaware line. Maximum erosion 2.13 m per year was recorded at 21st Street. The southern half of the shoreline underwent more erosion than the northern half. Deposition was recorded at 71st Street, and in the area between Ocean City station 27 and 120th Streets. Average deposition for the period at these locations was 30 cm per year.

Plot of the data for 1929-1947 (Figure 8) shows drastic changes both erosional and depositional, however, net change was an erosion rate of 60.8 cm per year. A major change to the total Maryland coast took place during the August, 1933 hurricane. An inlet broke through at the present location due to pressure build up of water in the bays. This inlet was subsequently stabilized with two jetties by the U.S. Corps of Engineers. Since the net beach sand movement is southward, the beach northward from the north jetty began to enlarge in width and toward the north. By 1947, deposition had occurred as far north as 25th Street. However, since the inlet is a barrier, the island on the south side of the inlet started to migrate westward. By 1947, 932 m south of the north inlet jetty the shoreline was 167 m west of the pre-1933 Hurricane position.

Inspection of figure 8 shows four areas of reversal or change over from accretion to erosion, and erosion to accretion. The range of this zone is arbitrarily selected and varies from rates of 60 cm per year erosion to 35 cm per year accretion. This graph shows that the shoreline erodes or accretes in a sinuous manner, that the rate and location of erosion or accretion is random. This would create a shoreline that has localized embayments and headlands.

The documented period of 1947-1965 indicates a net erosion rate of 50 cm per year. Figure 9 shows the graphed erosion-accretion rates for this period.

The period 1947-1965 includes one of the most injurious storms to affect Maryland's coast, the March, 1962 northeaster.

The U.S. Army Corps of Engineers in order to rebuild the 1962 storm ravished beach, pumped 760,000m^3 of sand from Assawoman Bay onto the beach

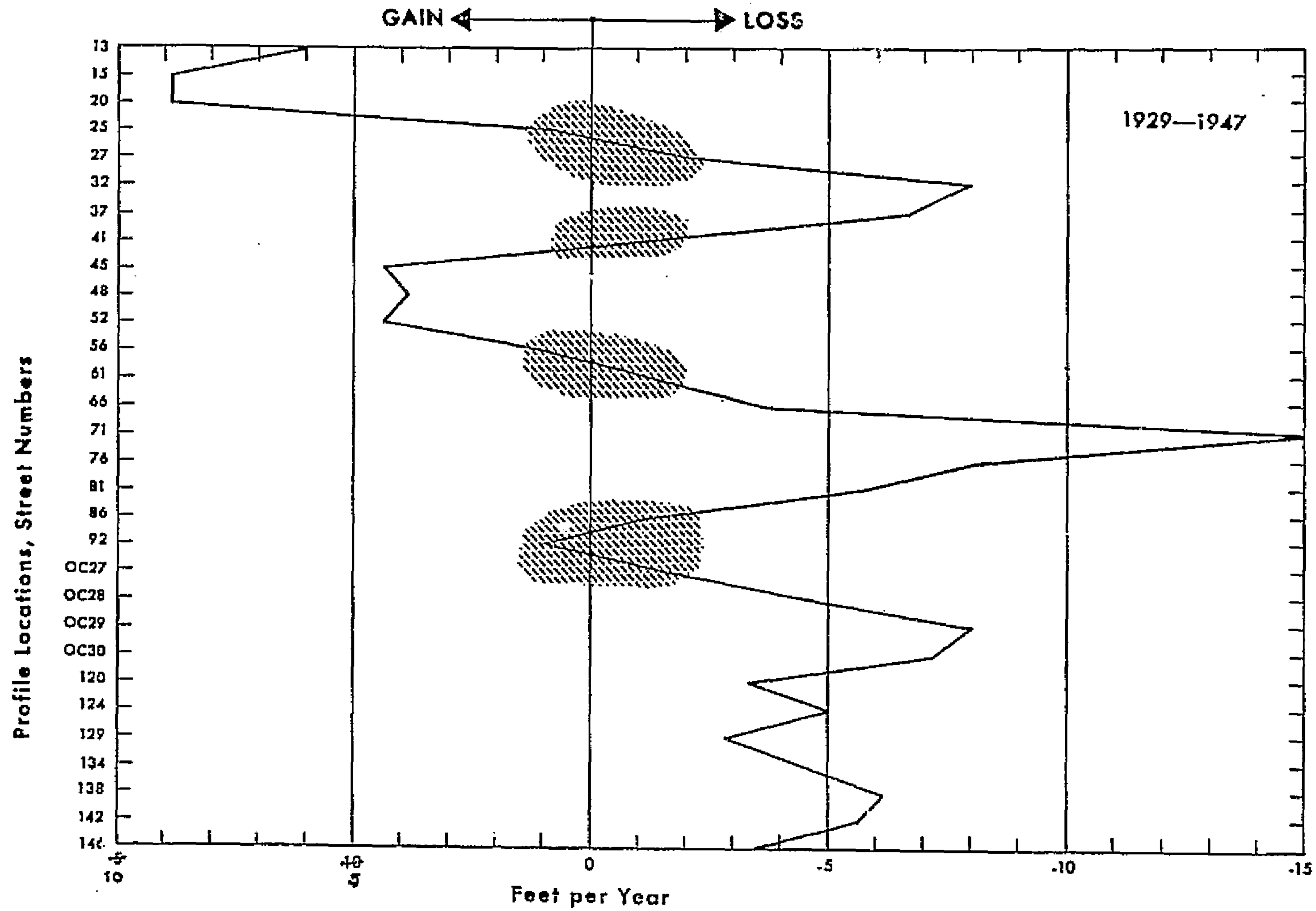


Figure 8 Graph of Rates of Erosion and Deposition for Ocean City, Worcester County ~~1947~~-1965
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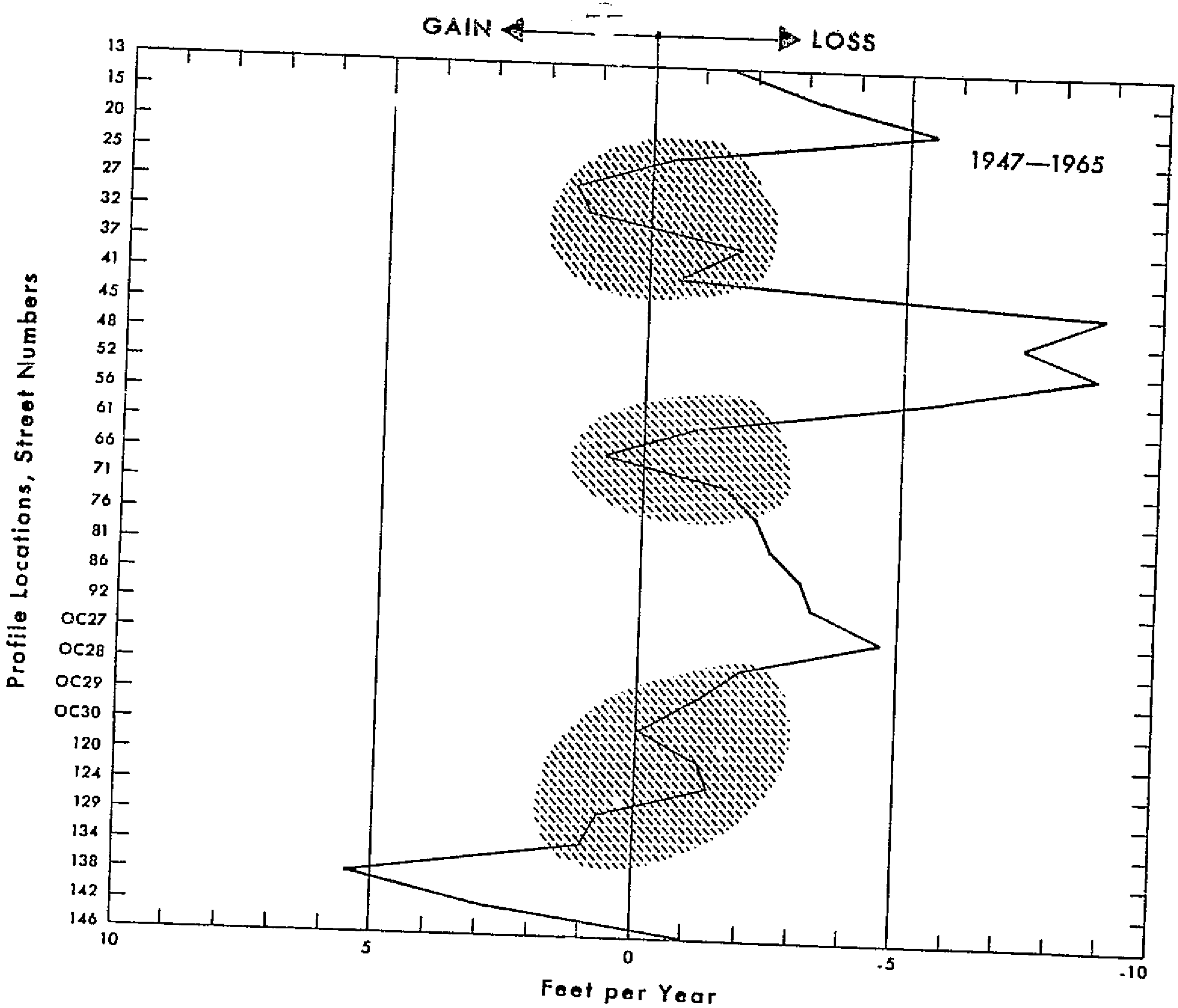


Figure 9 *Graph of Rates of Erosion and Deposition for Ocean City, Worcester County 1947-1965*

between the inlet and the Maryland-Delaware line. Combined efforts of the Federal, State, and City governments rebuilt the beach and erected an emergency dune. If the beach had not been rebuilt, one can speculate that erosion rates would be greater than measured in 1965.

During this period there are recorded three zones of reversal that varied from 40 to 60 cm per year of accretion and erosion, almost the same as those of the 1929-1957 period. The reversal area, 25th through 41st Streets is the same zone as for 1929-1947. The reversal area for 61st and 71st Streets almost overlaps the 56th and 61st Streets zone for 1929-1947. The reversal zone from Ocean City station 28 to 113th Street is the largest of the 1929-1947, 1947-1965 periods.

Comparison of the 1929-1947 and 1947-1965 periods established the fact that shoreline change along the coastline from the inlet to the Maryland-Delaware boundary takes place in a non-uniform pattern and reversal zones occur, but not necessarily at the same place. In other words, the geologic and hydrodynamic forces that shape the outline of the coastline are always actively at work but varying in intensity at different locations.

Comparison of the periods 1850 and 1965 is shown by figure 10. Net or average recession is 67 cm per year. Excepting the area from the inlet to North 1st Street, there are no areas of accretion along the entire Ocean City coast for the period 1850-1965. The 1850-1965 graph shows greatest net erosion to occur between 13th and 61st Streets, and the least between 92nd and 120th Streets.

OFFSHORE BARS

It is acknowledged that the profiles are only point data and that all

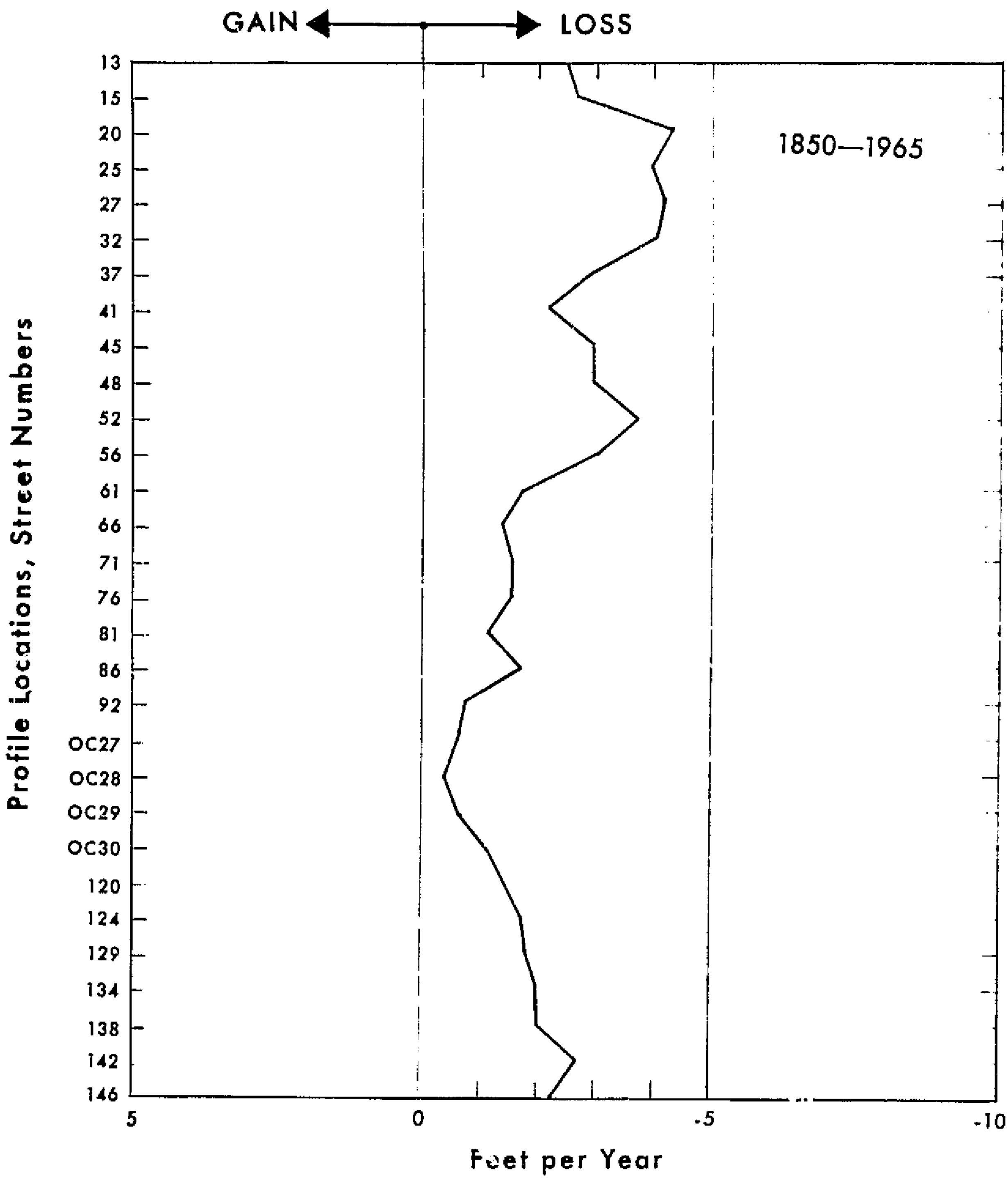


Figure 10 Graph of Rates of Erosion and Deposition for Ocean City, Worcester County 1850-1965

the intermediate changes and resulting effects are masked, however, the data comparisons are indicators especially since there is an 18 year coverage for each of the two periods 1929-1947, 1947-1965.

Upon first examination of the profiles it becomes apparent that there has been significant change in the nearshore bathymetry for both periods. Unfortunately, for the period 1929-1947 there is not enough data to define the bar. The 1965 profiles disclose that the bar is a non-uniform, irregularly shaped bottom structure. The bar was absent at 66th, 129th, and 134th Streets when the 1965 profiles were surveyed.

The period of 1947-1965 is somewhat better documented than 1929-1947, however, the bar is only documented by 1947 data to 41st Street. As already described, the profiles at 13th, 15th, and 20th Streets show erosion rather than accretion. At 13th Street, the erosion rate is 42 cm per year in contrast to 1.0 m and 1.7 m per year for 15th and 20th Streets. The offshore changes for 13th Street are considerably less than that for 15th and 20th Streets. The bar at 13th Street showed little or no change for 1947-1965. The bar at 15th and 20th Streets migrated at least 60.9 m shoreward.

The coastline between 25th and 41st Streets is a reversal zone with minimal erosion ranging from 12 cm to 42 cm per year. The amount of offshore change is relatively minimal at all five streets. The bar migrated shoreward at 25th, 27th, 32nd, and 41st Streets, 60.9 m, 51.8 m, 36.5 m, and 76.2 m respectively. At 37th Street, the bar migrated 24.3 m seaward. It would seem that the lack or small amount of offshore change has accounted for the minimal onshore changes. The migration of the bar apparently had little or no effect on shore changes in this reversal zone.

One normally thinks of an offshore bar as a linear structure paralleling the beach with lows and high peaks. Actually the bar along the Ocean City coast is a lobate, crescentic shaped structure. The nearshore mergings are elevated shallow areas and the outer bar crest is lower in elevation. Where the near shallow areas merge with the shoreline, a minor headland forms, separated by an embayment which faces its shallow offshore bar crest. The bar system creates headlands and embayments that give the shoreline a crescentic form.

A shallow water wave as it moves shoreward increases in height and breaks when it reaches depth equal its height. Average calm wave conditions at Ocean City create a breaking height of 90 cm to 1.2 m. The 1965 Corps profile bar depth ranges from less than 30 cm to 1.52 m. The seaward lobate portion of the bar is the deeper part with shallow headland near shore depths. The breaking waves will mirror to a degree the shape of the outer bar. Based upon these facts an attempt is made to map the outer bar through a breaking wave pattern. Figure 11 is a photo of ERTS-1 A/C flight dated August 12, 1972 showing the breaking wave pattern, headlands and embayments.

Measurements from ERTS-1 and Wallops flights were made of breaking wave conditions on August 12, 1972, October 20, 1972, February 12, 1973, March 23, 1973, May 17, 1973, August 6, 1973, and November 1, 1973. When offshore conditions were highly agitated, the wave breaking conditions were over 100 m eastward of calm condition breaking waves. The agitated periods were October 20, 1972, February 12, 1973, and March 23, 1973.

Figure 12 is a tracing of the bar and trough system from the June 8, 1952 aerial photograph that shows the crescentic, lobate shape very well. Although the shoreline is fairly uniform there are subtle headlands that have formed

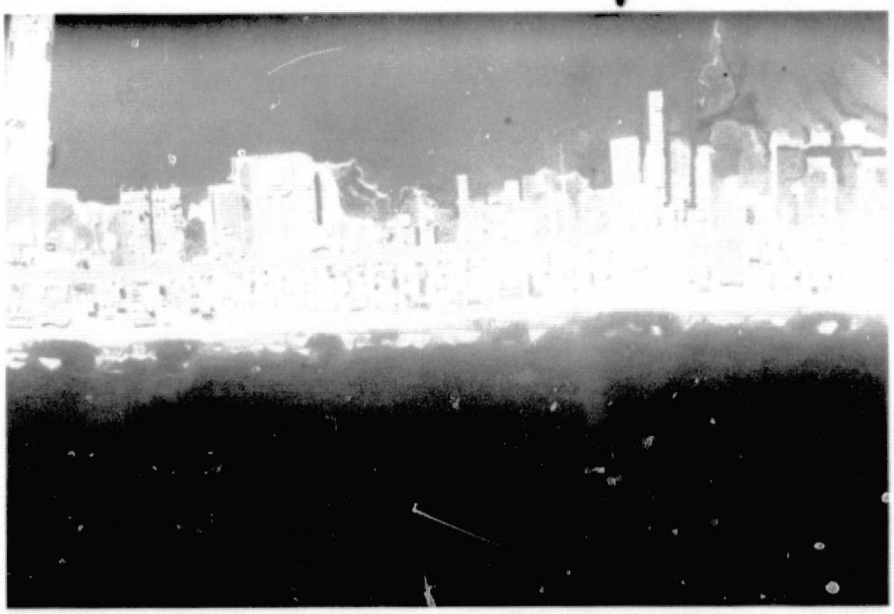


Figure 11 Photo of ERTS-1 Aircraft Support of Ocean City, Worcester County August 12, 1972 Showing Breaking Wave Pattern, Headlands and Embayments

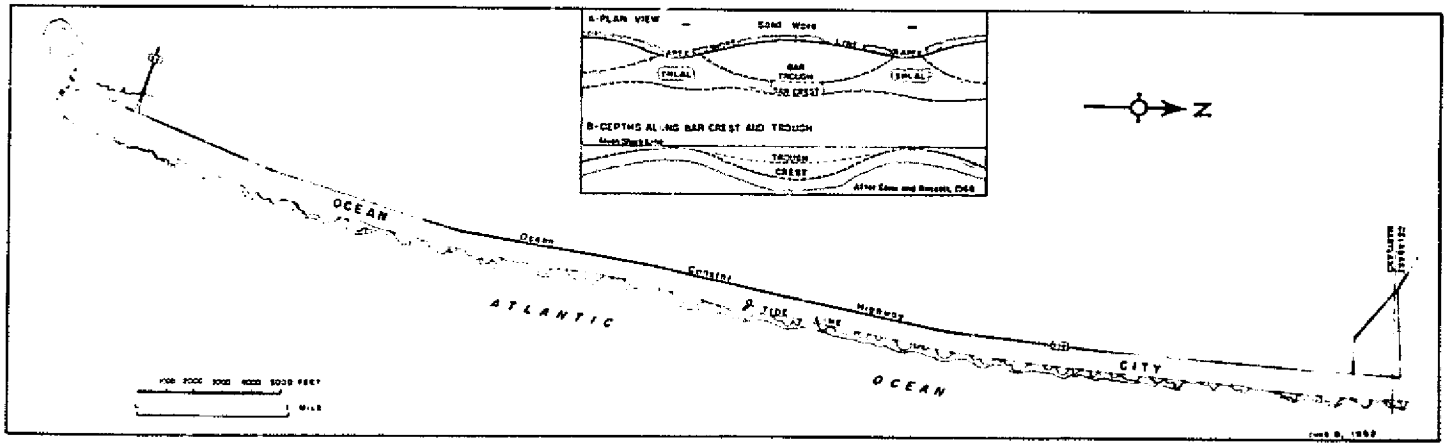


Figure 12 Map Showing Bar and Trough System of Ocean City, Worcester County June 8, 1952

where the shallow broad bar system merges with the shore. The length of the lobate bar systems range from 213.3 to 457.2 m and have a width that ranges from 60.9 to 106.6 m. From 13 to 61st Streets the bar has migrated landward about 15.2 m from the 1952-1965 general bar location. From 66 to 146st Streets the recent bar location is about in the same location as the 1952-1965 alignment. One of the implications as interpreted from this aerial data is the possible effect the bar location change will have on the shore or beach area from 13 to 61st Streets.

The bar as mapped by the U.S. Army Corps of Engineers in 1965 at their profile stations obviously ranges from shallow nearshore to seaward deeper portions. If the June, 1952 bar system was essentially the same as the 1965 system, a plot of profile stations should parallel or overlie each other. Plot of the bar data for these two dates does not disclose this similarity except at 56 and 81st Streets. As shown by figure 13, the two dates do not parallel or overlie each other although there is a general agreement of magnitude of amplitude alignment. The bar location at the Corps profile stations as mapped from ERTS-1 color IR underflight film for August 12, 1972, May 17, 1973, and November 1, 1973 show seasonal variation at the profile stations. An average composite line is drawn for these three dates and is shown in figure 13.

SAND WAVES

It has already been stated that the shoreline is generally sinuous and consisting of embayments and headlands which are related to the bar systems. Figure 12 insert shows the relationship of the bar and sand waves. These crescentic landforms have been recently described by Dolan (1971) with

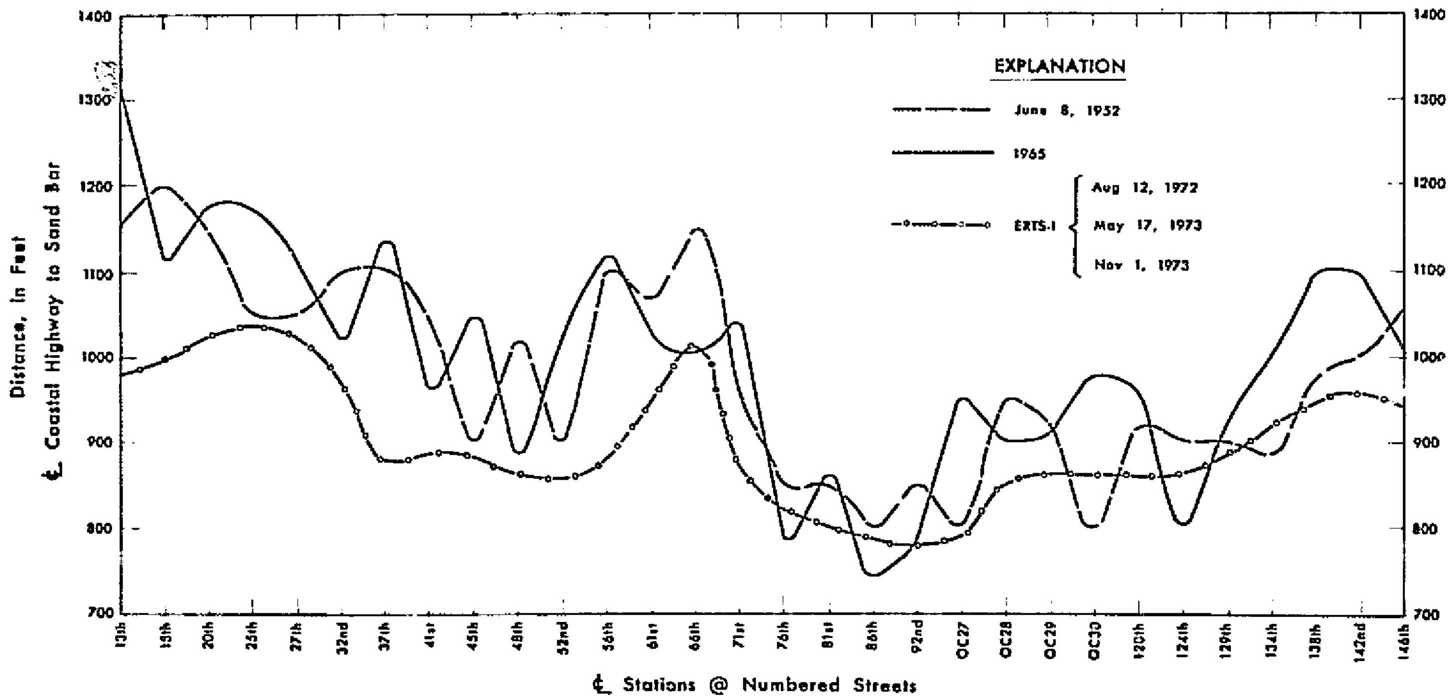


Figure 13 Graph Showing Location of the Bar at Selected Profile Stations at Ocean City, Worcester County, 1952, 1965, August 12, 1972, May 17, 1973 and November 1, 1973

particular attention to the grandbanks of North Carolina at Cape Hatteras. The proper descriptive term is "Sand Waves". Along the coast of North Carolina sand waves lengths ranges from 150 m to 1,000 m, and wave width averaging between 15 m and 25 m. The literature on the relationship between wave action and landward topographic expression of a beach is voluminous. One of the more recent inclusive papers on the subject is by Sonu and Russell, (1965) for an area north of Cape Hatteras at Nags Head, North Carolina.

Sand waves have been noted along the Ocean City coastline. Utilizing ERTS-1 underflight film, sand waves were mapped on August 12, 1972, October 20, 1972, January 16, 1973, May 17, 1973, and August 6, 1973. No sand waves existed during February 12, 1973, March 23, 1973, and November 1, 1973.

The length of sand waves ranged from 103.6 m to 594.3 m, averaging 332.2 m and width ranged from 9.1 m to 38.1 m averaging 18.9 m.

The following table lists, average length and width-amplitude of sand waves noted on the above dates.

Meters

	Length Average	Length Range	Width Average	Width Range	No. of Waves
August 12, 1972	305	105-578	17	11-26	15
October 20, 1972	245	15-355	23	15-31	15
January 16, 1973	344	104-520	15	11-26	14
May 17, 1973	361	143-594	18	9-38	11
August 6, 1973	408	370-463	21	18-23	3
Average	332		19		

Figure 14 is a graph showing location and length of sand waves for the date of occurence. From this presentation it becomes apparent that the sand waves do not persist in size or location during the year. The sand waves are obviously erased by agitated surf but soon afterward they begin to form in a different locations, in size and in number.

Headlands or the projection part of the sand waves are formed by the shallow near shore projection of the bar system that merges with the shoreline. Since the headlands change in location the bar system must also change.

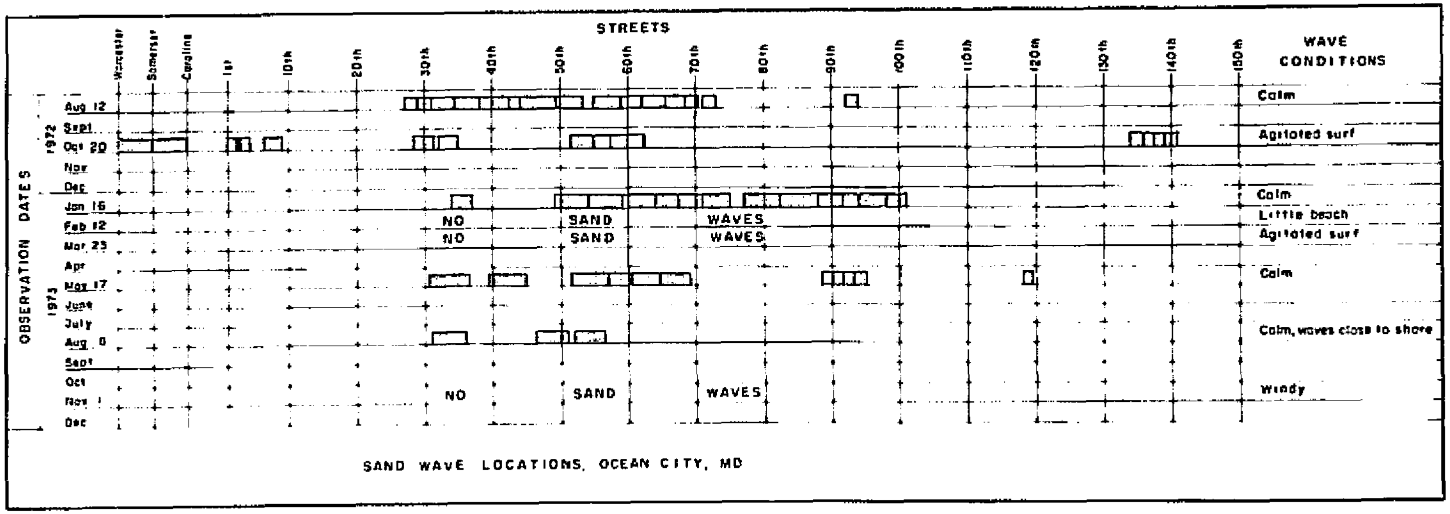


Figure 14 *Graph Showing Location and Length of Sand Waves of Ocean City, Worcester County, August 12, 1972; October 20, 1972; January 16, 1973; May 17, 1973 and August 6, 1973*

CONCLUSION

This report has shown by comparing historical shorelines of Ocean City, from the present inlet to the Maryland-Delaware line that reversal zones of erosion and accretion occur at different locations for different periods. The Atlantic Coast assumes at times a crescentic form called sand waves whose existence is related to shape and location of the nearshore bar. Because of climatic and wave conditions, the offshore bar is changed causing the obliteration of the sand waves. The sand waves in response to bar metamorphosis change size, location, and existence.

LINEAR DISTRIBUTION OF THE HIGH MARSH VEGETATION COMMUNITIES OF THE LOWER EASTERN SHORE AND ITS GEOLOGICAL SIGNIFICANCE

by
Randall T. Kerhin
Geologist

INTRODUCTION

One of the objectives of the Maryland Geological Survey's ERTS-1 investigation is to evaluate and apply ERTS-1 multispectral imagery to coastal zone processes in Chesapeake Bay. One site selected for analysis is Janes Island State Park located in Somerset County of the Lower Eastern Shore. Janes Island is composed entirely of tidal salt marsh fringed by 4-6 m wide beach. In the analysis of the beach distribution for Janes Island, the question was raised as to the immediate source of sand for the beach and nearshore system. One theory proposes that the sand source is in the immediate area and by shoreline erosion of the tidal salt marsh, sand is released to the nearshore environment. Using ERTS-1 imagery, the interior of Janes Island was scanned, and it became apparent that different reflectance levels on the imagery were distributed in a linear, northeast trending pattern. The purpose of this report is to describe these unique linear patterns using Anderson's et al (1973) and Klemas' et al (1973) methods of wetland vegetation detection and signature returns from ERTS-1 imagery and ground-truth verification.

SIMILAR GEOMORPHIC LANDFORMS

The detection of geomorphic features on the Lower Eastern Shore was reported by Rasmussen and Slaughter (1955). They reported on the distribution

of the Maryland Basins, shallow oval basins bounded by low sand rims distributed from tidal salt marshes to the upland areas. They proposed formation by sedimentation around isolated icebergs. Pettry (1973) reported on similar landforms for the Virginia Eastern Shore and described them as craters with a distribution from sea level to upland areas. The geomorphic features in this report tend to be linear with a distinct trend rather than oval. It is not known at this time whether the landforms mapped in this report are related to the "Maryland Basins" of Rasmussen and Slaughter or the "Virginia craters" of Pettry.

ANALYSIS OF MULTISPECTRAL IMAGERY FROM ERTS-1

The physical, chemical, and biological characteristics of a tidal salt marsh have prompted many research investigations. One approach to such investigations is the application of remote sensing, particularly ERTS-1 imagery to mapping and monitoring the tidal salt marshes. Anderson, et al (1973) and Klemas, et al (1973) utilized ERTS-1 multispectral imagery and aircraft support to analyze and map the vegetation distribution of a tidal salt marsh. Both investigators concluded that ERTS-1 resolution limits fall short of the scale needed for detailed vegetation mapping, but a general vegetation distribution is mappable based on the difference in reflectance levels of the marsh vegetation. Anderson, et al (1973) reported that within the Nanticoke salt marsh in Dorchester County, two major vegetation communities are detectable; Juncus roemerianus/ Scirpus sp./ Spartina alterniflora in the lower marsh areas and Spartina patens/ Distichlis spicata/Iva frutescens/ Baccharis halimifolia in the high marsh communities. The signature of the two major vegetation communities demonstrate that the low

marsh sequence has a reflectance level close to that of a water signature (dark in grey scale comparison) whereas the high marsh community has a comparatively higher reflectance level. This distinct difference in reflectance levels allows for general low marsh/high marsh delineation. Using Chapman's (1960) general classification scheme to differentiate a low marsh and a high marsh based on the period of continuous exposures or the tidal inundation of the land; a low marsh (low reflectance level) is subjected to daily tidal flooding and a high marsh (high reflectance level) is subjected to flooding only in spring and storm tides. The significance of the high marsh area is that it represents topographic high areas within a tidal salt marsh. By mapping the high marsh distribution based on different reflectance levels coupled with the physiographic setting of the low and high marsh with respect to the tidal cycle, inferences can be drawn as to the geomorphology of a tidal salt marsh. These criteria aided by ground-truth verification were the basis for detection of these unique geomorphic features.

Manual image interpretation of MSS band 7, December 3, 1972 (E-11331-15144) and January 9, 1973 (E-1170-15193) revealed a distinct distribution pattern for the high marsh vegetation community (i.e., topographic high areas) for Janes Island and regionally, the Lower Eastern Shore. To aid in the detection of the high marsh vegetation pattern, color enhancements were made using an I^2S color additive viewer located at the Chesapeake Bay Data Center, Wallops Station, Virginia. The purpose was to enhance the reflectance levels, of the high marsh vegetation and, thereby, identify the topographic high areas in the tidal salt marsh. Two dates were selected for enhancements; July 7, 1973 (E-1349-15141) and June 1, 1973 (E-1331-15141). On the I^2S system, illumination was set at 9 or the highest possible illumination.

(for photographic purposes) for all four MSS bands. The filters were selected by best visual enhancement and were: MSS band 4-blue filter, MSS band 5-blue filter, MSS band 6-green filter, and MSS band 7-red filter. In using the I^2S color additive viewer, it became apparent that enhancement techniques and settings are individually suited and the settings here selected for enhancement of the high marsh vegetation may not be the best settings for other investigators.

In the manual image interpretation of MSS band 7 and the I^2S enhancements, the distribution of the high marsh vegetation reflects two distinct linear patterns in the Lower-Eastern Shore of Maryland. The linear patterns are believed to be ridge systems. On the east side of Tangier Sound, the linear trend is in a northeast-southwest direction. This trend is most pronounced on Janes and Deal Islands and is traceable across the sub-estuaries existing in the area. On the west side of Tangier Sound, a northwest-southeast trend is evident, particularly on Smith, South Marsh and Bloodsworth Islands. Projecting the trends of the two ridge systems into Tangier Sound, a pattern of convergence is very apparent. Actual detailed mapping of the linear ridge systems is not possible because of the resolution limits of ERTS-1 imagery. The different reflectance levels of the wetland vegetation communities, regionality of ERTS-1 imagery, and color additive enhancements allowed for detection and general delineation of these linear ridges.

AIRCRAFT SUPPORT AND GROUND TRUTH VERIFICATION

The initial scanning procedures of the MSS imagery allowed for detection of the linear ridges, but detailed mapping was accomplished with the use of aircraft support and ground truth. The regionality of the linear ridges and

associated trend patterns is best seen using aircraft support photography of August 22, 1972 as a basis for mapping (figure 15). Using color infrared photography, the same criteria of differing reflectance levels of low and high marsh apply. As noted on ERTS-1 imagery, two distinct trends are observed from lower Hooper Island to the Maryland-Virginia line. Progressing northward into Hooper and Taylor Islands in Dorchester County, the linear ridges become more difficult to recognize and to map from either ERTS-1 MSS imagery ~~on~~ aircraft support. The general coastal environment changes from a dominant low marsh/high marsh environment to one of high marsh/upland. This transition of environment changes the reflectance levels and signature returns of the vegetation communities. For Taylor and Hooper Islands, the signature is comparatively close in reflectance level and delineation of the high marsh vegetation is difficult. Although distinct linear ridges cannot be seen, a linear pattern in the form of topographically controlled drainage alignment, lineation of cultural features in particular, countr roads, and some isolated linear ridges can be detected. Observations ι J.S. Department of Agriculture aerial photographic mosaics and a SLAR mosaic at the Chesapeake Bay Data Center revealed a concentration of linear ridges trending in a northwest-southeast direction. Within the general trend, small concentrations or subsets of linear ridges in a northeast-southwest direction occur. Because of the lack of necessary ground truth for Taylor and Hooper Islands, a representative map of the linear features is not presented in this report.

HIGH MARSH VEGETATION-SIGNATURE RETURN CORRELATION

In order to verify the high marsh signature with field investigation, Janes Island was selected as a test site. As shown by Figure 16, three distinct sets of linear ridges are present on Janes Island and all trend in a northeast direction. Mr. William Sipple, Wetland Biologist for the Maryland

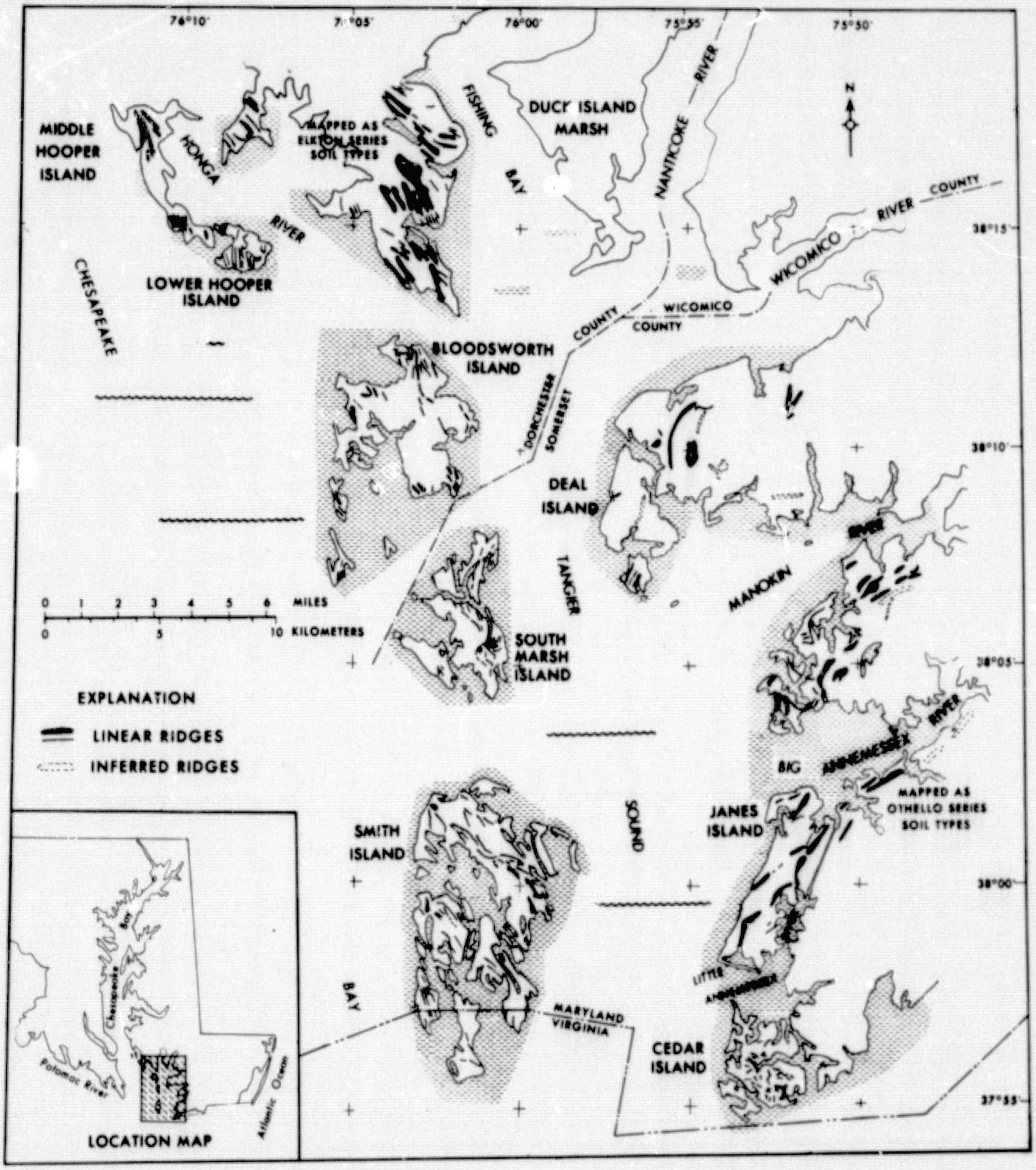


Figure 15 Regionality of the Linear Ridges and Associated Trend Patterns. Two Distinct Trends are Mapped from Aircraft Support, a Northwest and a Northeast Trend

Department of Natural Resources, constructed a general vegetation distribution which was correlated with the reflectance levels observed on ERTS-1 MSS imagery and aircraft support (Figure 17). Mr. Sipple states:

> Most of the linear structures at Janes Island appear to be vegetated by either high marsh or upland (very low upland). The high marsh is dominated by the Spartina patens-Distichlis spicata vegetation type as well as that type mixed with shrubs such as Iva frutescens and Baccharis halimifolia. The upland sites are vegetated by either trees (deciduous and some coniferous) with shrub (e.g., Myrica cerifera, Baccharis halimifolia) and herbaceous (e.g., Panicum virgatum, Spartina patens) understories. These linear landforms occur within larger low marsh masses dominated principally by Spartina alterniflora and low and intermediate marshes dominated by Juncus roemerianus.

The correlation of the vegetation communities with the reflectance levels laid the foundation for detection and delineation of the linear ridges. Similar vegetation types have been found on Smith Island linear ridges and on lineations northeast of Janes Island (Sipple, Pers. Comm.). Metzgar (1973) reported that Janes Island is represented by 502 acres of Type 16 wetland (Coastal Salt Meadow rarely covered by tidal water because of elevation) and 2373 acres of Type 17 wetland (Irregularly Flooded Salt Marsh). This breakdown of the wetland type by Metzgar (1973) conforms to the distribution of the vegetation communities described by Sipple (Pers. Comm.). Therefore, Type 16 wetland geomorphically represents the linear ridges on Janes Island.

SUBSURFACE GEOLOGY OF A LINEAR RIDGE

Six locations were selected for shallow 1.2 m bucket auger samples, three locations on a linear ridge and three locations in the intermediate to low marsh. Table 3 is the general stratigraphic section for the six

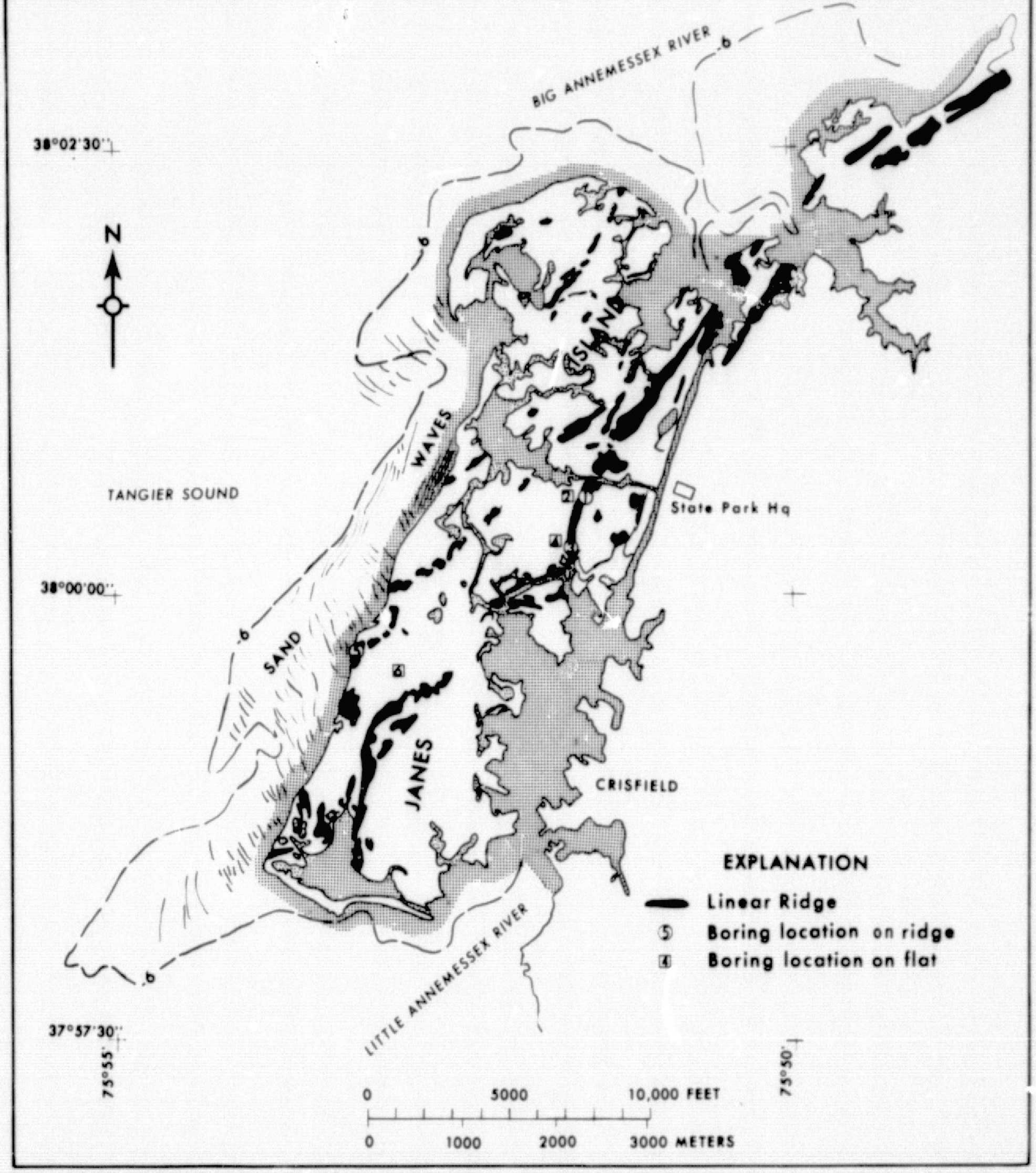


Figure 16 *Linear Ridge Distribution and Trend Pattern for Janes Island. Three Distinct Sets Trending Northeast are Delineated*

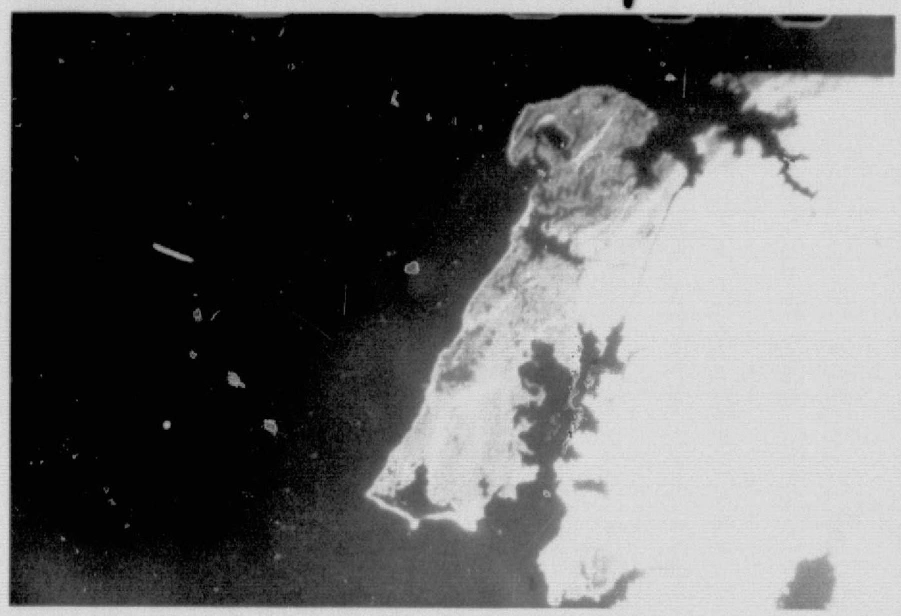


Figure 17 Linear Ridges Exhibit a High Reflectance Level which Correlates with High Marsh Vegetation

locations and Figure 16 shows the location with respect to Janes Island. Locations 1, 3, and 5 are located on a major linear ridge and locations 2, 4, and 6 are in the intermediate marsh (Juncus roemerianus) fringing the flanks of the linear ridge. No auger holes or samples were obtained for the low marsh sequence. In the linear ridge, a 10-20 cm root zone, (possibility an active soil horizon) overlies a brown-tan, firm clay grading into a gray clay with a sand matrix. Approximately 76 cm below the surface, a red-stained, medium sand with a clay matrix is present to the bottom of the auger hole. At location 3, the brown-tan clay grades directly into the medium sand whereas in location 5 the brown-tan is absent and the gray clay under the root zone grades into the medium sand. The general vertical profile description of the linear ridge is a 10-20 cm root zone followed by a clay layer to approximatley 90 cm overlying a red-stained medium sand.

Locations 2, 4, and 6 were located on the flanks of the linear ridge in the intermediate marsh. Below a root zone, a saturated, highly organic, dark gray clay is the dominant sediment type. Depending on the exact location of the bore hole with respect to the axis of the linear ridge, the dominant sediment type is either a saturated, highly organic dark gray clay or a dark gray to brown clay with a small percentage of sand. The dark gray to brown clay was sampled at location 4 on the flanks of the linear ridge closest to the axis, and the highly organic clay was encountered at locations 2 and 6 farthest from the axis in the lower marsh sequence. The medium sand found on the linear ridge was not encountered in locations 2, 4, and 6 but may be present at a deeper depth. This is suggested by the small percentage of sand found in some of the samples at location 4. Three borings taken by the Maryland Port Authority in a tidal flat on the east side of Janes Island

Logs of Janes Island, Ridge Auger Holes

TABLE 3

Location 1 South side of Hodson Wharf Channel on linear ridge system

Thickness (Centimeters)	
10	Root system, dark brown
10-30	Brown-tan, firm clay
30-61	Brown-tan clay with small percentage of sand, appearance of iron-stained sand
61-76	Brown-tan clay
76-101	Gray, firm clay with percentage of sand
101-121	Medium sand with clay matrix, reddish in color appears well-sorted

Location 2 South side of Hodson Wharf Channel, west of location 1 near edge of _Juncus roemerianus_

0-23	Organic, root zone
23-30	Organic clay peat
30-61	Dark gray, highly organic clay

Location 3 On linear ridge, south of location 1

0-20	Root zone
20-76	Brown-tan clay with sand increase downward
76-91	Medium sand, some clay

Location 4 West of Location 3 near edge of _Juncus roemerianus_

0-15	Organic, root zone
15-91	Dark gray (almost black) organic clay, highly saturated
91-106	Sandy clay, gray to tan, approximately 20% sand

Location 5 On linear ridge at shoreline intersection

0-15	Root zone
15-91	Gray, firm clay
91-106	Gray clay with medium sand matrix
106-	Grayish-brown sand with tan clay matrix

Location 6 East of Location 5 by _Juncus roemerianus_ and _Spartina alterniflora_

0-10	Overwash, wind-blown sand
10-106	Dark gray to black, highly saturated clay, no recovery below 106cm, hole fell in

describe a brown, sometimes silty, medium to coarse sand, 5 and 7 feet below mean low water. Texturally, the sands in the tidal flat appear to correlate with the sand found in the linear ridge but at a greater depth in the tidal flat. A generalized cross-section of the linear ridge might have the medium sand dipping underneath the thicker low marsh sequence into the nearshore environment (figure 18).

RELATIONSHIP OF SOIL TYPE TO THE LINEAR RIDGES

The onlap sequence of the low marsh onto the linear ridge and transition of vegetation type suggests conversion of the linear ridges to low marsh. August (1969) reported for Dorchester and Somerset counties that conversion of the high marsh is an active process with sea level rise and land subsidence as the major mechanism. Recent soil survey reports for Dorchester and Somerset counties suggest which land and soil types are vulnerable to tidal salt marsh conversion. The Elkton Series (low phase) in Dorchester County and the Othello Series (low phase) in Somerset County are the major soil types converted to a tidal salt marsh (Matthews, 1963, Matthews and Hall, 1966). Both soil types are poorly drained and found in low-lying areas along the shoreline which makes these soil types susceptible to conversion. The proximity to tidal influences and not the characteristics of the soil allow for tidal marsh conversion.

In comparison of the linear ridge distribution and the soil survey maps, the major soil series of the Elkton and Othello generally overlay the linear ridges.

In Dorchester County, (Taylor and Hooper Islands) distribution of the Elkton Series exhibits a distinct linear, northwest-southeast trend. Though linear ridges were not mapped in this area, the linear pattern of the Elkton

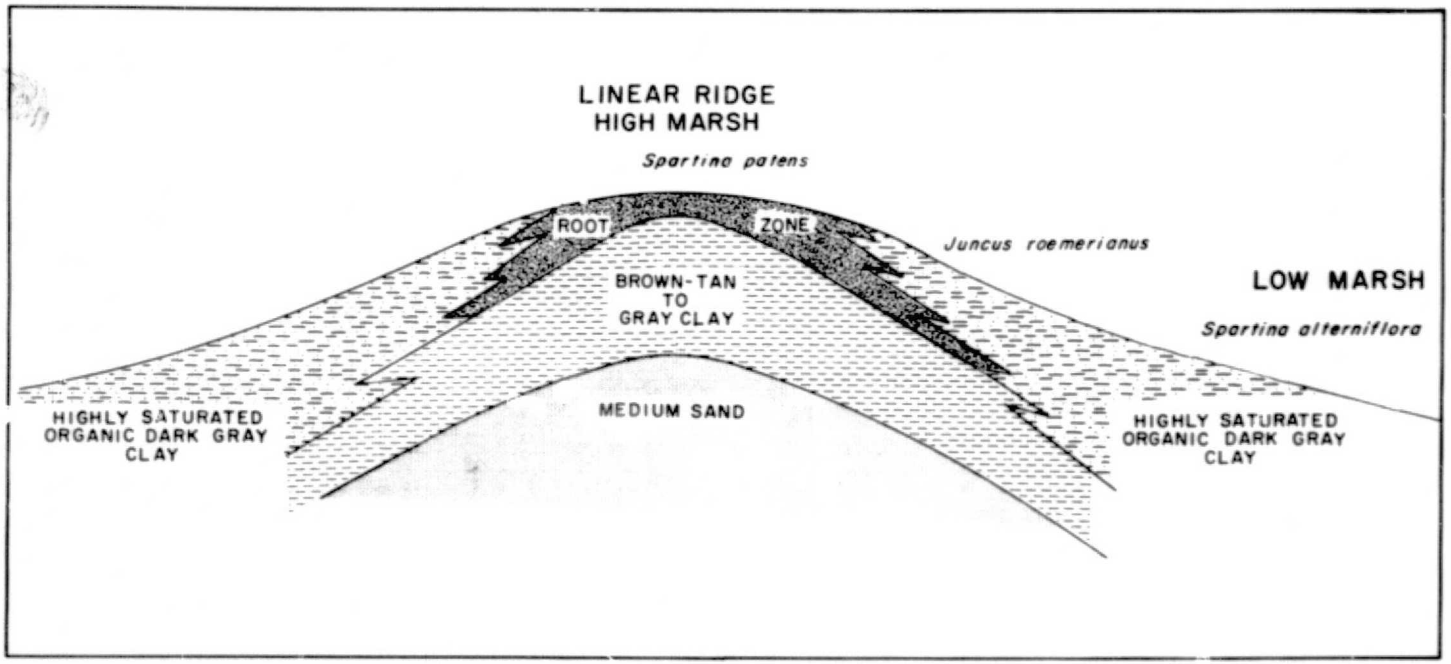


Figure 18 Generalized Cross-Section of a Linear Ridge Based on Shallow Auger Samples and Correlation with Bore Holes in a Tidal Flat Area

Series as well as lineation of the drainage pattern and culture strongly suggest the presence of linear ridge systems in the area. In the Lower Eastern Shore tidal marshes, particularly in Somerset County, the soil type was not mapped. Projecting the linear ridges on Janes Island landward, the linear ridges match the general trend and pattern of the Othello Series along some of the sub-estuaries. Mr. Richard Hall (Pers. Comm.) stated that the sediments in the auger holes in the linear ridge are similar to the Elkton Series and not the Othello Series as mapped for Somerset County. He also stated that soil similarity and mapping procedures may result in minor discrepancies in soil typing. The good correlation of the linear pattern, trend, and sediment description of the linear ridges and major soil types is indicative of tidal marsh conversion. The linear ridges may be considered as upland areas being actively converted to tidal salt marsh, but as Elliot (1972) pointed out the profile of the marsh "soil" is maintained and expanded by deposition rather than through the action of any of the "soil forming processes". A better understanding of the subsurface geology and geological processes must be obtained before the question of whether the linear ridges are geomorphically constructural features or are formed by the process of selected conversion of upland to low marsh can be answered.

INTERSECTION OF LINEAR RIDGES WITH THE SHORELINE

Tracing the linear ridges westward across Janes Island, two of the linear ridges intersect the shoreline on Tangier Sound. At the point of intersection, exposure of the linear ridges on the surface is difficult to recognize. The beach profile exhibits a small dune system with a gently-sloped beach 9-12 m wide. The beach has trangressed over the leading edge

of the tidal salt marsh, exposing this edge to wave activity and erosion. Cropping out at the exposure is a one-foot thick active marsh and root zone and a two-foot thick brown-tan clay. Differential erosion along the root zone/brown-tan clay contact has produced a wave-cut bench with a ten foot seaward projection of the brown-tan clay. Historically, this area of Janes Island has experienced an average 90 m of shoreline erosion since 1849 (Singewald and Slaughter, 1949) and the presence of the brown-tan clay is suggestive of seaward extension of the linear ridges.

Offshore of the shoreline intersection are a series of sand waves trending in the same general northeast-southwest direction and having a wave length of 92-122 m (figure 19). The migration pattern of the sand waves is to the southwest along a seaward projection of the linear ridge axis. The migration is evident by the elongated projections of the 2.0 m contour in this direction. Comparisons of the 1901 and 1949 hydrographic survey charts show a seaward progression of the 2.0 m contour for this time period. This is also the area where a major bend in the channel of Tangier Sound approaches Janes Island. With respect to the coastal processes, the dominant wind direction and velocity is from the northwest generating a longshore transport of littoral drift to the south. At the southern terminus of Janes Island, the dominant southerly longshore transport of littoral drift is evident by a massive south-west trending shoal area offshore of Old Island Point and secondarily, a southeast projecting recurved spit, now a man-made barrier beach. Slaughter (1973) reported a seasonal fluctuation of littoral drift to the north, but not of the magnitude to produce a zero net transport for Janes Island. Ryan (1952) reported that the sand flats of Tangier Sound appear to be of submerged mainland and that tidal currents are diverted around the flats and not across

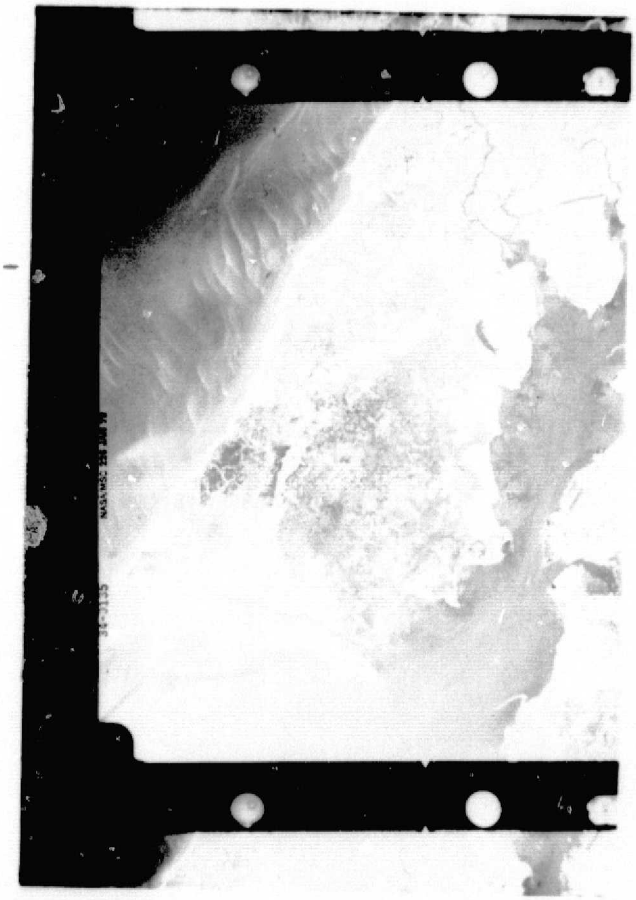


Figure 19 Sand Wave Trending in a Northeast-Southwest Pattern Coincides with Seaward Projection of a Linear Ridge with the Shoreline

them. Thereby, generation and migration of the sand waves are induced by northwest generated waves, and they are not tidal current bedforms. The mechanism appears to be diversion of the longshore current offshore in a southwest direction producing nearshore circulation cells. Whether the diversion of the longshore current is controlled by the subsurface seaward extension of the linear ridges or by a complex wave refraction pattern produced by the closest of the main channel of Tangier Sound is not known. Undoubtedly, more investigation and research is needed to answer these questions, but the striking coincidence of the linear ridges and sand waves trend direction is suggestive of a direct geological relationship.

CONCLUSIONS

As reported by many investigators, remote sensing, particularly ERTS-1 multispectral imagery, can be used to map the vegetation distribution of a tidal salt marsh. A low reflectance level responds to a low marsh community (Spartina alterniflora and Juncus roemerianus) whereas a high reflectance level correlates with a high marsh vegetation community (Spartina patens, Distichlis spicata, Iva frutescens and Baccharis halimifolia). The significance of the vegetation type is related to elevation, which in part determines the amount and duration of tidal flooding. Using ERTS-1 multispectral imagery and aircraft support, the distribution of the high reflectance levels (high marsh-high topographic areas) for the Lower Eastern Shore is confined to two distinct trending linear ridge systems. On the western side of Tangier Sound the linear ridges trend in a northwest-southeast pattern and on the eastern side the linear ridge systems trend in a northeast-southwest pattern with a projected convergence at the Maryland-Virginia line.

The northeast-southwest trending linear ridges on Janes Island were selected as a ground truth site for signature return and vegetation type correlation. The linear ridges correlate with high marsh/upland vegetation and appear on the aircraft support and ERTS-1 imagery as areas of high reflectance level. A shallow, stratigraphic section of the linear ridge displays a 10-20 cm root zone followed by a brown-tan to gray clay layer to 88 cm overlying a red-stained, medium sand. The intersection of the linear ridge with the shoreline exposes a wave-cut bench of the root zone and brown-tan clay layer found in the linear ridge. Offshore, sand wave bedforms trend and migrate in a southwest direction along the seaward extension of the linear ridges suggesting a possible geological relationship of the linear ridges with the sand waves. The relationship of the linear ridges with the marsh

formation of Janes Island still needs further investigation.

The ability of ERTS-1 imagery to record different reflectance levels and the regionality of the imagery has been useful and applicable to mapping a geologically unique series of linear ridge systems. Because of the lack of detailed information, no affirmative conclusions or interpretation can be made and more questions are raised than answered. Some of the questions which need further investigations are:

1. What is the origin and age of the linear ridges?
2. What relationship do they have with the development of a tidal salt marsh and conversion of the Elkton and Othello soil types?
3. How do the ridges relate to the Pleistocene and Holocene history of the area?

Many more questions can be asked but only further investigation is going to supply the necessary information for affirmative answers.

VISUAL OBSERVATIONS OF SUSPENDED SEDIMENTS AND NEARSHORE ICE SIGNATURES IN CHESAPEAKE BAY

by
Randall T. Kerhin

INTRODUCTION

In each of the preceding sections of this report, specific research objectives and applications of ERTS-1 imagery were discussed and evaluated. In applications of ERTS-1 to these specific objectives, certain geological phenomena were observed on the imagery. The purpose of this section is to describe an unique suspended sediment pattern and nearshore ice formation that was observed on the imagery even though ground truth was not adequately obtained.

DISCUSSION

As noted by many ERTS-1 investigators, MSS band 4 and 5 are applicable to detection of suspended sediment patterns. This delineation of suspended sediments is directly related to the prevailing current patterns in the area. The overpass of ERTS-1 on April 9, 1973 immediately followed a 1.5 + inch rainfall in Maryland. The heaviest rainfall was recorded for the coastal plain counties on the western shore. With the heavy rainfall on April 8, 1973 examination of MSS band 5 (E-1260-15201) for April 9, 1973 revealed a heavy concentration of suspended sediments in Chesapeake Bay and its tributaries (Figure 20). A major concentration is visible within the turbidity maximum. As defined by Schubel (1971), the turbidity maximum occurs in the upper reaches of an estuary in the transistion zone from estuary to the tidal reach of the river. For Chesapeake Bay, this transistion zone (turbidity maximum) extends from Turkey Point to Tolchester. The seaward front of the turbidity maximum moves up and down the Bay in response to the Susquehanna River flow. On MSS band 5 (E-1260-15201), the apparent movement along the turbidity maximum is southward bordering the shoreline of Kent County. At the southern terminus, a suspended sediment wedge is visible moving across the Love

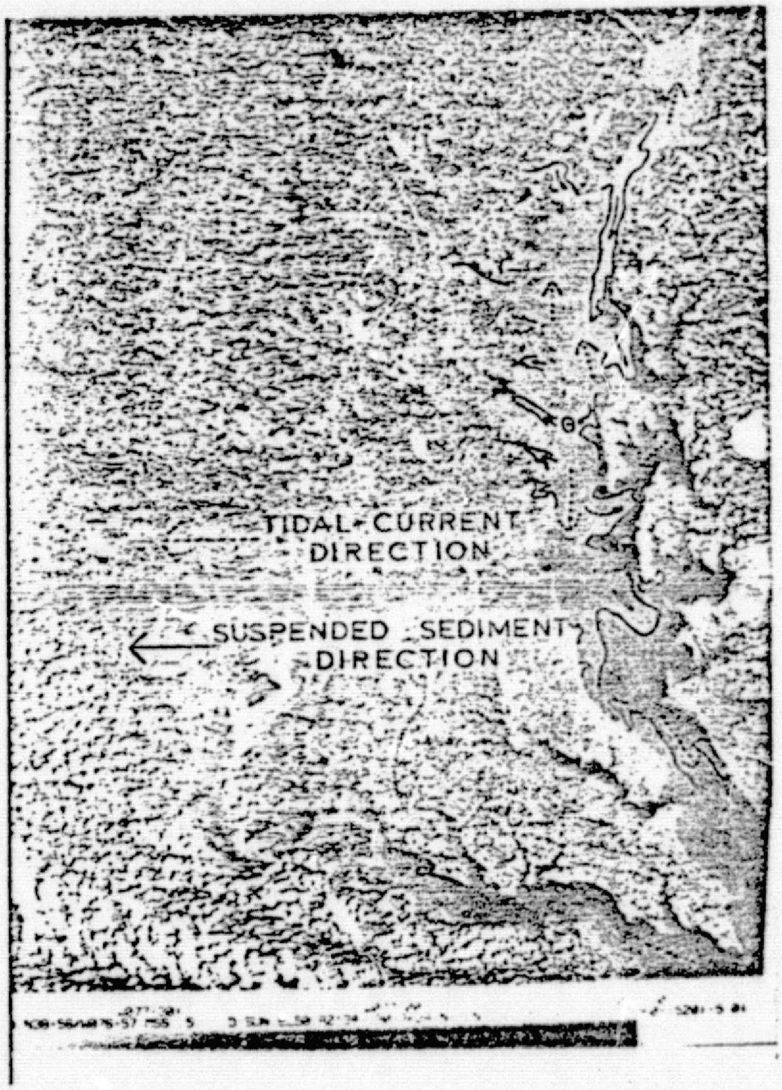


Figure 20 *General Suspended Sediment Pattern Mapped Directly on April 9, 1973 MSS Band 5 Imagery. Imagery Immediately Followed a Heavy Rainfall on April 8, 1973. Note Apparent Upstream Pattern of Transport for some of the Tributaries*

Point Shoal into Chester River. Palmer (1972) constructed a sedimentological model indicating bidirectional current flow at the mouth of Chester River where upstream bottom flow transports bedload sand and silt from the Bay into the River. He also reported that the net downstream surface flow is subject to tidal fluctuation which may relate to the suspended sediment pattern observed in some of the tributaries on the western shore. In the Magothy, Severn, South and Rhodes Rivers, the apparent suspended sediment pattern is transported from the Bay into the rivers. These tributaries have minor fresh water inflow and are basically Chesapeake Bay water. Pritchard (1971) reported that in early spring, the salinity differential between the Bay and tributaries allow the surface water of the Bay to flow into the tributary. Whether the suspended patterns for the tributaries reflect the sedimentation model as constructed for the Chester River or a salinity differential as defined by Pritchard (1971) is not known. A third possibility is the suspended sediment patterns reflect the tidal cycle at the time of the imagery. Superimposed on the suspended sediment patterns is the predicted tidal direction from the tide tables. This does not necessary indicate the actual tidal direction which may be storm related. Whatever the actual transport mechanism may be, MSS band 5 for April 9, 1973 indicates an unique sedimentation pattern of upstream transportation of suspended sediments from the Bay into the tributaries.

Another area of high concentration of suspended sediments is the Bush and Gunpowder Rivers. Historically, this area has had a high influx of sediments from upland sources. Agriculture and sand and gravel operations are the major industries in the watershed. The Bird River, a small tributary to the Big Gunpowder River, shows a high concentration of suspended sediment.

As observed on the April 9, 1973 MSS band 5 imagery, the suspended sediments from the Bird River are transported across the mouth of the Big Gunpowder River and are deflected southward along Gunpowder Neck. Observations based on a December 3, 1972 imagery indicate that the suspended sediments from Bird River are deflected southward by the net river flow of the Big Gunpowder River. Based on these two observations, an unusually high river flow for the Bird River can be assumed for the period of April 9, 1973.

Another interesting observation noted on ERTS-1 imagery is the formation of beach and nearshore ice. Ice formation was recorded on the imagery for January 9, 1973 and February 13, 1973. An intervening imagery, January 26, 1973 recorded no ice formation indicating a freeze-thaw-freeze condition. The presence of ice is easily misinterpreted on the imagery. On MSS band 4 and 5, ice formation along the beach zone is recognizable as ice but nearshore ice in the form of thin sheet ice has a signature return resembling nearshore turbidity (Figure 21 a & b). Band 6 and 7 records nearshore ice but beach ice formation resembles a white beach signature without ice. In all four bands beach and nearshore ice can be misinterpreted without adequate ground truth or low-level aircraft support.

Figure 22 is an ice distribution map for January 9, 1973 constructed on a scale of 1:1,000,000. On the western shore the greatest ice concentration is in the Baltimore-Harford Counties river systems. The Bush, Big Gunpowder, and Bird Rivers have beach and nearshore ice. Thin sheet ice is dominate in the open water areas of these tributaries and is mappable southward to Middle and Back Rivers. For Anne Arundel, Calvert, and St. Mary's Counties, only small pockets of ice are observed on the imagery.

On the eastern shore, the mouth of the Sassafras River is completely frozen and at Grove Point, ice-push ridges are evident along the shoreline (Figure 23).

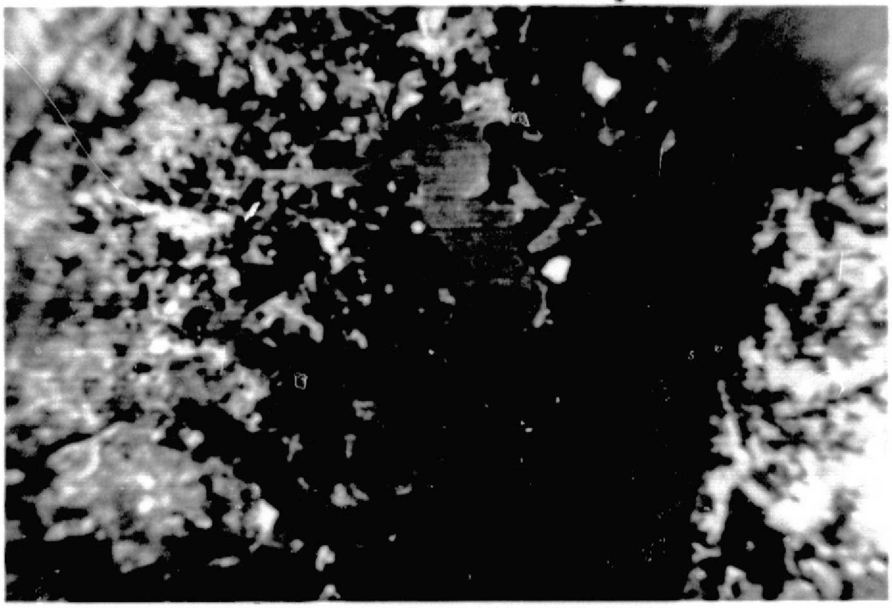
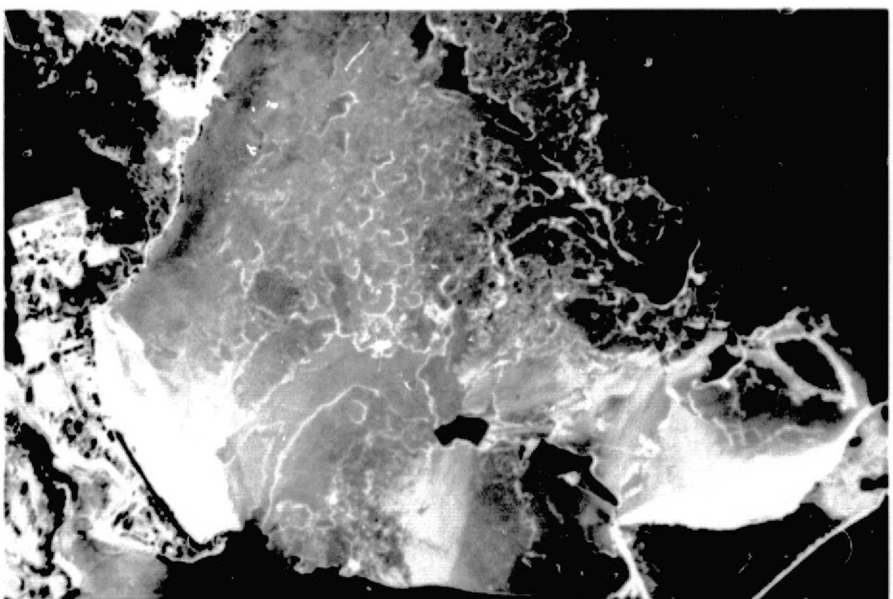


Figure 21 *Misinterpretation of Nearshore Ice as Suspended Sediment*
a) Represent ERTS-1 imagery and the apparent suspended sediment load



b) Aircraft support of a section of the area which exhibits nearshore ice. Both ERTS-1 imagery and A/C were taken on the same day January 8, 1973

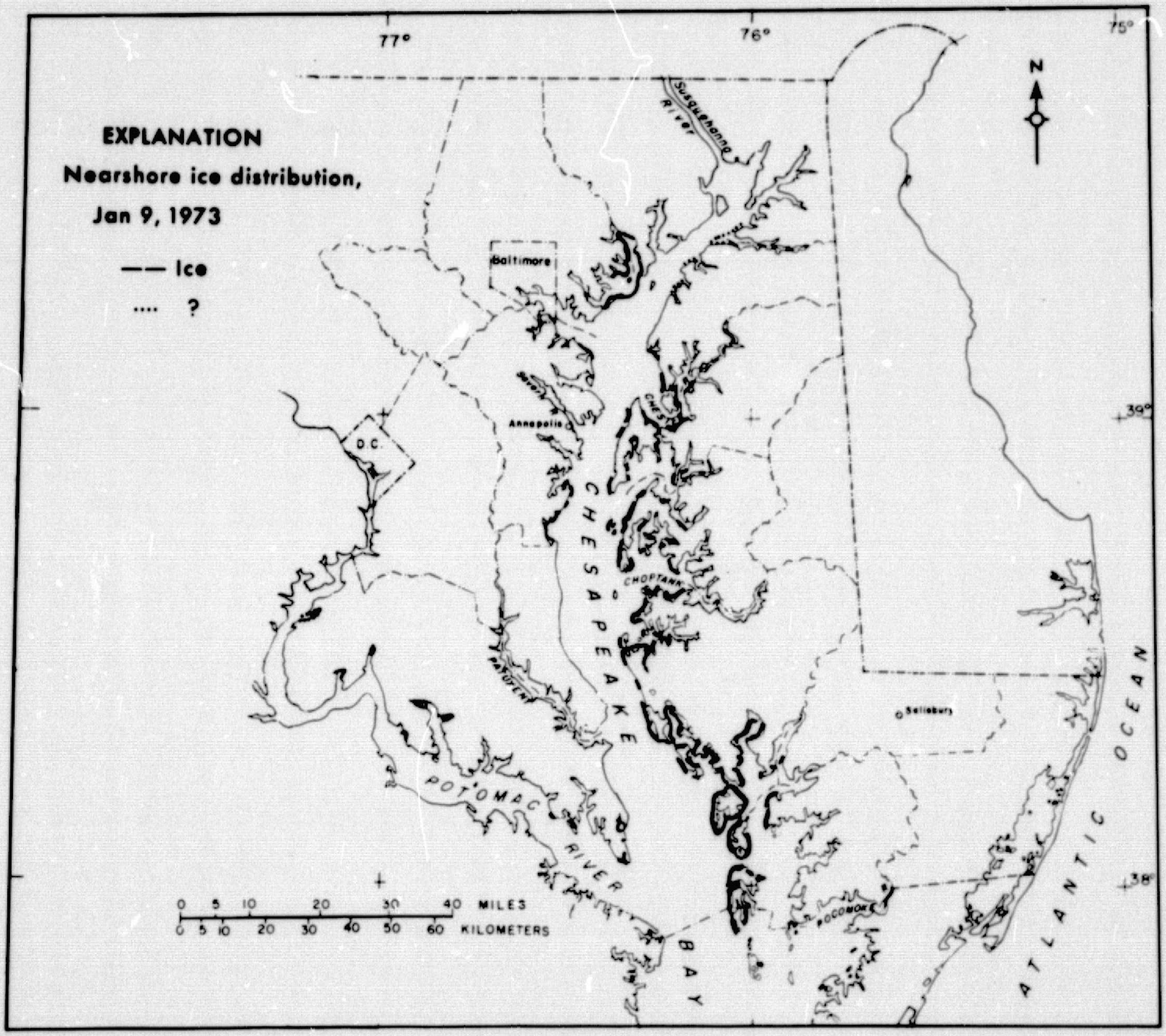


Figure 22 Ice Distribution Map for January 9, 1973 Compiled form ERTS-1 MSS Band 7

Figure 23 *Ice Push Ridges at Mouth of Sassafras River, Grove Point. Ground Truth was taken 4 days after ERTS-1 Overpass*

These ice-push ridges are similar to the ice-push ridges described by Davis (1972) for eastern Lake Michigan. The greatest concentration of ice on the eastern shore is in Dorchester and Somerset Counties. Most of the tidal inlets and wetlands are covered with ice. Small boat channels are completely frozen and access to open water appears impossible.

The ice distribution for February 13, 1973 is basically the same pattern as January 9, 1973 (Figure 24). Baltimore and Harford Counties have the greatest concentrations of ice for the western shore whereas Dorchester and Somerset Counties have the greatest ice concentration for the eastern shore. Generally the ice formations appear less for February 13 than for January 9, 1973.

SUMMARY

Observations of MSS band 5 dated April 9, 1973 exhibited an unique sedimentation pattern for Chesapeake Bay. Following a 1.5 inch rainfall, heavy concentration of suspended sediments is observed on the imagery, particularly in the area of the turbidity maximum. An apparent southward movement of the suspended sediments is mappable. At some of the major tributaries, a suspended sediment wedge is observed showing an upstream transportation direction. Whether the actual transport mechanism is a salinity differential, two-layered bidirectional current flow, or actual tidal flow can not be concluded from observations of one imagery. It is apparent that further investigation into the actual transportation of suspended sediments of Chesapeake Bay is warranted.

During January and February, 1973, a freeze-thaw-freeze condition existed with beach and nearshore ice observed on ERTS-1 imagery. Beach ice can be mistaken for a beach signature on MSS band 7 and nearshore ice can be

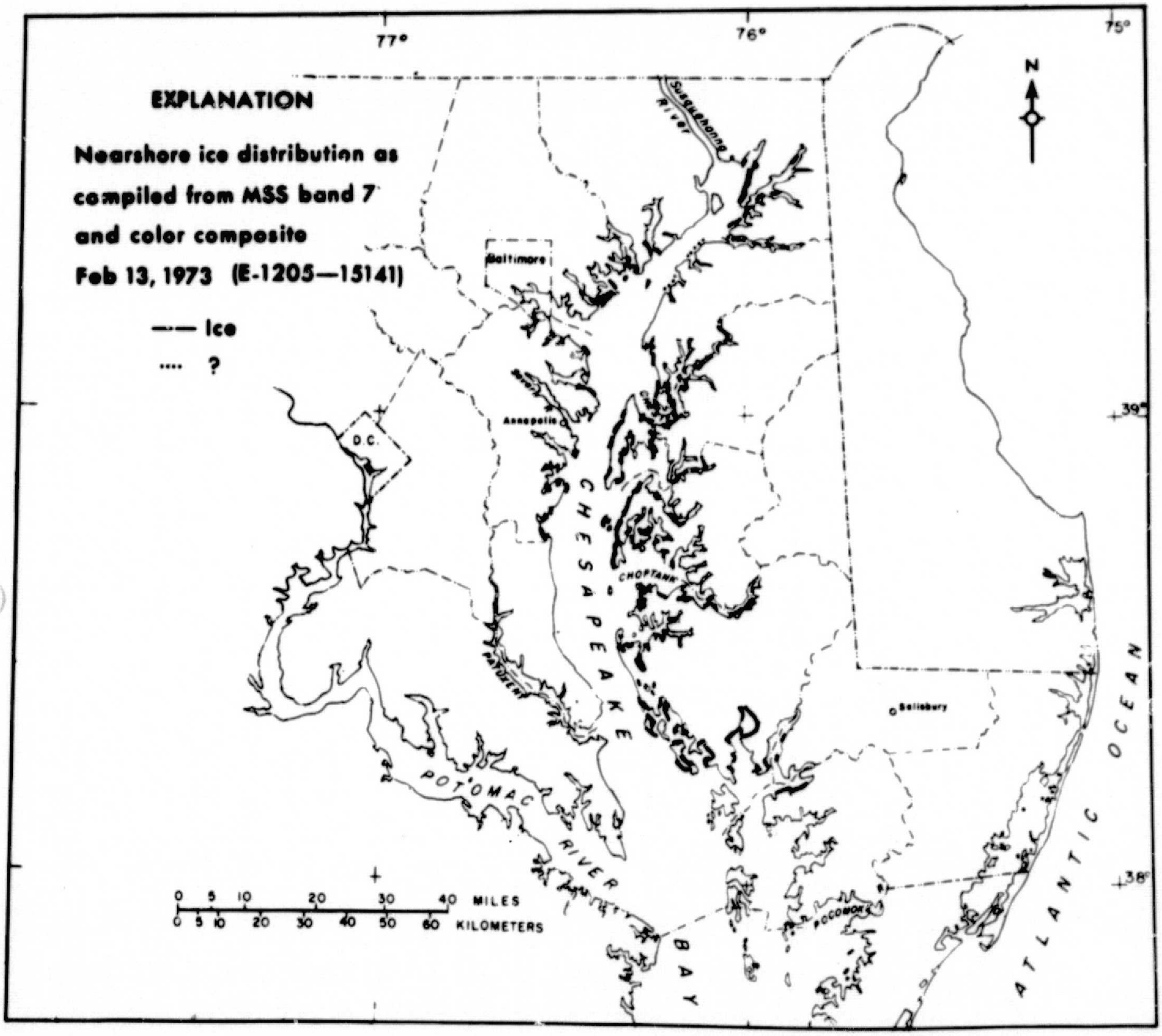


Figure 24 *Ice Distribution Image for February 13, 1973, basically same Pattern as January 9, 1973. A Thaw Period (January 26, 1973) Intervenes the Two Freeze Conditions*

misinterpreted as nearshore turbidity on MSS band 5. The significance of mapping beach and nearshore ice for Chesapeake Bay is twofold. First, the dominant water-oriented industry in the winter is the shellfish industry. Harvesting the oysters and clams is dependent on free access to the Bay from small boat harbors. Monitoring nearshore ice by ERTS-1 can be used to indicate potential harbors for ice-breaking procedures. Second, the role of ice in shoreline erosion may be significant in area of unconsolidated sediments. Using ERTS-1 to indicate areas of high ice concentration, ground truth can monitor shoreline erosion.

CONCLUSIONS

The general format of this final report is to present specific investigations dealing with the application of ERTS-1 imagery to Maryland geology. Within each section report are specific conclusions and evaluations obtained from the analysis of ERTS-1 imagery. Presented here is a summarized statement of conclusions based on each section report.

<u>Section 1</u> - Differentiation of Serpentinitic from Non-Serpentinitic Ultramafic Rocks in ERTS-1 MSS Imagery.

Recent field work in Baltimore County revealed that the signature returns of serpentinitic and non-serpentinitic rocks correlates with the vegetation cover and general land-use pattern. Non-serpentinitic supports a vigorous hardwood flora and some farming practices with a red signature return whereas serpentinitic rocks have stands of Virginia Pine and greenbriar with little land-use development. In Maryland Piedmont, bedrock lithology and structure are enhanced only to the extent that land-use is geologically dictated.

<u>Section 2</u> - Observation of Linear Features in the Maryland Piedmont as shown by ERTS-1 MSS Imagery and Aircraft Support Photography.

Two promient sets of linear features are detected on ERTS-1 imagery. One set is comprised of two belts trending N45°E and are composed of Sam's Creek Metabasalt (western belt) and quartzose facies of the Wissahickon Schist (eastern belt). The second set of linear features is detected between the western and eastern belts of the first set and trend N20°E. These subtle features, such as lineaments, maybe of significance not only in the interpretation of the regional geology, but also may have practical importance in environmental geology, such as indicating zones of high groundwater yields, mineralization, or shattered and deeply weathered bedrock.

<u>Section</u> <u>3</u> - Maryland Chesapeake Bay Beaches - General Distribution and Classification

The effectivelness of ERTS-1 multispectral imagery to detect small-scaled beach features with strict manual image interpretations is dependent on two factors; the contrast at the land/water interface and the linearity of the beach system. High contrast-short beach systems (barrier beach across a sub-estuary)are as detectable on ERTS-1 imagery as are low contrast-long beach systems (St. Mary's Co.).

Through ground truth verification, four misinterpretations are recognized. The most common condition for misinterpretation of the beach signature is fill material behind a bulkhead. The other misinterpretations are nearshore turbidity, vertical sedimentary cliffs and shoreline erosion control structures.

Based on ERTS-1 imagery and aircraft support data, beaches of Chesapeake Bay are classified as broad and narrow beaches based on the width of the backshore. The predominate beach type is narrow beaches existing throughout the Bay while the broad beaches are confined to the western shore. The broad beaches accounted for 120 km of beach length and are dominate in Calvert and St. Mary's counties. With the use of ERTS-1 imagery, actual ground truth mapping is not needed for the major beach systems and ground truth observations can be concentrated in areas of questionable interpretation.

<u>Section</u> <u>4</u> - The Relationship of Nearshore Longshore Bar and Sand Waves along Ocean City, Maryland.

This report has shown by comparing historical shorelines of Ocean City, from the present inlet to the Maryland-Delaware line that reversal zones of erosion and accretion occur at different locations for different periods. The Atlantic Coast assumes at times a crescentic form called sand waves whose existence is related to shape and location of the nearshore bar. Because of climatic and wave conditions, the offshore bar is changed causing

the oblitoration of the sand waves. The sand waves in response to bar metamorphosis change size, location, and existence.

Section 5 - Linear Distribution of the High Marsh Vegetation Communities of the Lower Eastern Shore and its Geological Significance.

As reported by many investigations remote sensing, particularly ERTS-1 multispectral imagery, is applicable to mapping the vegetation distribution of a tidal salt marsh. Using ERTS-1 multispectral imagery and aircraft support, the distribution of the high reflectance levels (high marsh-high topographic areas) for the Lower Eastern Shore are distributed as two distinct trending linear ridge systems. On the western side of Tangier Sound the linear ridges trend in a northwest-southeast pattern and on the eastern side the linear ridges trend in a northeast-southwest pattern with a projected convergence at the Maryland-Virginia line.

The northeast-southwest trending linear ridges on Janes Island were selected as a ground truth site for signature return and vegetation type correlation. The linear ridges correlate with high marsh/upland vegetation appears on the aircraft support and ERTS-1 imagery as high reflectance level. A shallow stratigraphic section of a linear ridge displays a 10-20 cm root zone followed by a brown-tan to gray clay layer 90 cm overlying a red-stained medium sand. The intersection of the linear ridge with the shoreline exposes a wave-cut bench of the root zone and brown-tan clay layer found in the linear ridge. Offshore, sand wave bedforms trend and migrate in a southwest direction along the seaward extension of the linear ridges suggesting a possible geological relationship of the linear ridges with the sand waves.

Section 6 - Visual Observations of the Suspended Sediments and Nearshore Ice Signatures in Chesapeake Bay.

Observations of MSS band 5 dated April 9, 1973 exhibited an unique sedimentation pattern for Chesapeake Bay. Following a 1.5 inch rainfall, heavy concentration of suspended sediments is observed on the imagery, particularly in the area of the turbidity maximum. At some of the major tributaries, a suspended sediment wedge is observed showing an upstream transportation direction.

During January and February, 1973, a freeze-thaw-freeze condition existed with beach and nearshore ice observed on ERTS-1 imagery. Beach ice can be mistaken for a beach signature on MSS band 7 and nearshore ice can be misinterpreted as nearshore turbidity on MSS band 5.

OVERALL CONCLUSIONS

In evaluating ERTS-1 multispectral imagery to the overall objectives of the Maryland Geological Survey, these general conclusions can be made:

1) Only generalized mapping can be accomplished with ERTS-1 imagery and detailed geological mapping as performed by the Environmental Geology Division is not directly applicable to extensive use of ERTS-1 imagery.

2) Small-scaled geological features whether in the Piedmont or coastal zone are not adequately recorded on the imagery for any detailed analysis. Enlargements of ERTS-1 imagery for purposes of small-scaled detection presents another problem of scan line interferences. Misinterpretation of scan lines for small-scaled geological features is very possible. This is the case of the attempted mapping of the nearshore bedforms in the Bay.

3) Manual image interpretation of ERTS-1 imagery is generally not the best method of data analysis. It is apparent that a wealth of information

is recorded in each scene of ERTS-1 imagery that requires some machine processing to enhance and to interpret adequately.

4) The major application of ERTS-1 imagery is in construction of reconnaissance maps of certain geological features. Differentiation of serpentinitic from non-serpentinitic rocks is an example of reconnaissance mapping which aided in the detailed mapping program. The significance of reconnaissance mapping is that the maps allow for ground truth time to be conducted in areas of questionable interpretation. This is apparent by the construction of the beach distribution maps where major beach systems were delineated allowing ground truth time in remote areas of the Bay.

5) The imagery best suited in meeting the objectives of the Maryland Geological Survey are MSS band 7 and color composite. Although MSS band 5 was designed for sedimentation studies, recognition of beach and nearshore depositional features were not adequately recorded on the imagery. This is partly due to the strong suspended sediment signature on MSS band 5 which interferes with any accurate interpretation of beach and nearshore depositional features.

In summary, ERTS-1 multispectral imagery had only limited use to the Maryland Geological Survey. The primary function was to supplement detailed mapping programs with a regional overview and reconnaissance maps. In essence, ERTS-1 imagery has supplied the regional data base and interpretation needed for future study analysis of the State of Maryland. The application of ERTS-1 imagery to Maryland geology will not end with this contract period but will be applied as future programs are initiated.

RECOMMENDATIONS

The following recommendations are compiled from suggestions by the staff geologists of the Maryland Geological Survey who reviewed and applied ERTS-1 imagery to their research programs.

The major recommendation deals with imagery scale and resolution. Generally the scale differences and resolution limits are beyond the scales of the geological mapping programs. It is recommended that if good resolution can be maintained or improved through enlargements of ERTS-1 imagery to a mapping scale of 1;62,500, a greater application of ERTS-1 to geological mapping is foreseen. Coupled with the limited ERTS-1 resolution capabilities is the problem of scan line interference particularly in detection of small scaled geological features. Alleviation of scan line interference either by improvement in machine processing or the multispectral scanner would improve the application of ERTS-1 to mapping small-scaled features.

The wealth of information presented on ERTS-1 imagery does not lend itself to strict manual image interpretation. To enhance ERTS-1 imagery, each investigator should have available to him/her facilities or machine products that would enable the investigator to apply and evaluate ERTS-1 imagery to the fullest extent.

In the investigation of coastal sedimentation, ERTS-1 is very applicable to suspended sediment patterns but beach and nearshore sedimentation is not adequately recorded on the imagery. To compliment the suspended sediment studies, more emphasis on beach sedimentation with respect to multispectral technology, ground truth techniques, and machine processed products is highly advisable. This area of coastal research is not directly applicable to the now functioning ERTS-1.

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